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PROGRESS REPORT
of the
WESTERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION
AGRICULTURAL RESEARCH SERVICE

This progress report includes a summary of the current research of the Division and a preliminary report of progress made during the preceding year. It is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1967 and June 30, 1968. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Western Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture, Albany, California.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

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INTRODUCTION

This report summarizes the current program and progress during FY 1968 on research conducted at the Western Utilization Research and Development Division, Agricultural Research Service. A few of the more significant recent accomplishments are described.

Research Area Covered by this Report

The following research problem areas are within the scope of the Western Utilization Research and Development Division: (1) new and improved fruit and vegetable products; (2) new and improved food products from field crops; (3) new and improved feed and industrial products from field crops; (4) new and improved poultry meat and egg products; (5) new and improved products from wool and mohair; (6) expansion of foreign markets for U.S. farm produce; (7) protection of food supplies from harmful microorganisms and naturally occurring toxins; (8) alleviating soil, water, and air pollution; and (9) insure food products free from toxic residues from agricultural sources.

The farm commodities dealt with in this report are the cereal grains, wheat, rice, and barley; alfalfa and other forage crops; wool and mohair; citrus, subtropical, deciduous and other fruits; tree nuts; potatoes, dry beans and peas and other vegetables; castor, safflower and other western oilseeds; and poultry and eggs. (Some phases of research on certain of these commodities are pursued in other Utilization Research Divisions.)

Pharmacological research for four Utilization Research Divisions is conducted at the Albany laboratory of the Western Division, and is described in the report as it applies to various subject areas. (Progress on commodities assigned to other Divisions should be found in their reports.)

Organization of the Division

The Western Utilization Research and Development Division is one of five Utilization Divisions of the Agricultural Research Service. Research and development are carried on for the Western Division by a staff headquartered in the Western Regional Research Laboratory, Albany, California. A smaller Department-owned laboratory is operated in Pasadena, California, and additional laboratory space for two scientists is provided by arrangement with California Institute of Technology. Laboratory space and facilities in Puyallup, Washington, are utilized through a cooperative arrangement with Washington State University, Institute of Agricultural Sciences; and laboratory space and facilities in Honolulu, through a cooperative arrangement with the University of Hawaii.

The Albany research staff is organized into six commodity-oriented Laboratories (Cereals, Field Crops, Fruit, Poultry Products, Vegetables, and Wool and Mohair), two functional Laboratories (Pharmacology, and Engineering and Development), and a Pioneering Laboratory concerned with basic studies of plant enzymes. The staff at Pasadena is organized as the Subtropical Fruit Laboratory. The Western Regional Research Laboratory at Albany also houses the Division Director's staff, the staff required for Administrative support of the Division, and that responsible for Plant Management--that is, operation of the buildings, facilities, and grounds.

Division scientists and engineers not only conduct or supervise research in their own experimental facilities, but also greatly extend the scope and influence of their work by planning and supervising developmental activities carried on by cooperating private firms, processor organizations, or industry groups, and by arranging for research by well-qualified scientists elsewhere under research contracts and grants. In addition, certain grants of research funds are placed with investigators in foreign countries; the cost of these foreign research efforts on behalf of American agricultural interests is borne by Public Law 480 funds.

Examples of Recent Accomplishments of the Western Utilization Research and Development Division

New Food-Protein Concentrate from Wheat. Major flour milling companies are producing a new type of protein-rich concentrate for use in foods. Based on Department research, the new flour is derived from byproduct fractions normally disposed of in animal feeds at low returns. Amber in color and mild in flavor, the concentrate contains 20 to 35% protein and is rich in the scarce amino acid lysine. Useful in such domestic products as baked goods and ready-to-eat breakfast cereals, it is also being used in high-protein products for food aid programs overseas. One of the latter is a protein-enriched flour for Asiatic baked products that has a bright future for commercial exports. Most significant is the availability of a protein concentrate for human feeding at a cost of about 5¢ per pound at the processor level. More than a million tons of food-grade concentrate can be produced per year, and nearly as much of a less refined version will be available for use as an upgraded poultry-feed ingredient. A total increase in net value of nearly \$50 million will result. Major flour millers will benefit directly, and growers will share indirectly.

More Efficient Rice Drying. Department scientists have helped the rice drying industry handle the rapidly increasing demand for dryer capacity. Utilization research showed that increasing the air temperatures and shortening the tempering periods between multiple passes in columnar dryers resulted in increased capacity, increased yield of whole kernels, and more efficient use of heat. Recently, Department scientists developed more accurate, simplified control methods for the faster drying. In 1966 they tested these methods under field conditions in cooperation with industry and the California State Agricultural Extension Service and Experiment Station.

The capacity of existing dryers was increased by 40%. This procedure has allowed the industry to handle increased drying loads without construction of new dryers. The improved process is now in extensive commercial use. Potential annual savings are \$2 million for California alone.

Improved Shrinkproofing Treatment for Wool. Experimental industrial trials have demonstrated the superiority of a new shrinkproofing treatment for wool. The new treatment, in which a polyurea finish is applied, is technologically superior to earlier polymer processes. Specific advantages include more effective shrinkproofing, softer handle for the treated fabrics, improved stability of the reactant baths, simplification of process control, and lower chemical costs. This process is being actively evaluated by manufacturers of woven fabrics, blankets and knit goods, as well as by producers of wool-containing durable press apparel. The improved quality of product and simplification of process control should accelerate the commercial use of treated wools with major benefits to the consumer in convenience and lower maintenance costs of machine-washable wool garments. Sheep raisers should profit from greater use of wool in garments. The fabric producer also benefits from economies in manufacturing costs made possible by the use of this new polyurea process.

Flavor Stability of Navel Orange Juice. A long standing problem of navel orange juice is the development of a delayed bitterness. When first prepared the juice is not bitter but bitterness gradually develops on standing or heating. It has been known for many years that the source of this bitter taste is an intensely bitter substance known as limonin, but how this substance is formed in the juice was unknown. Now Department research has shown that a non-bitter precursor is concentrated in the structural tissues of the fruit. When these tissues are ruptured during the extraction process, this substance is converted to the bitter limonin that renders the juice unpalatable. An enzyme which effects this conversion has been isolated and characterized. A method was developed by the Department and adopted by industry for measuring the potential maximum bitterness of the juice. These results provide information needed to develop practical methods for preventing or minimizing this bitter off-flavor.

"Dry" Caustic Peeling of Potatoes. Potato processing, excluding chips, increased steadily from 1 to 7 billion pounds annually between 1955 and 1965 and now creates a liquid waste disposal problem equivalent to the domestic sewage from 9 million people. Eighty percent of the Biochemical Oxygen Demand (BOD) arises from the peeling operation.

An essentially dry caustic peeling process for potatoes has now been developed through the pilot plant stage. With this technique, as much as 95% of the peel waste can be removed from the potato without the use of water. This avoids 75% of the BOD arising from present processing methods and keeps nearly all of the lye out of the plant effluent. This accomplishment can potentially avoid the need for investment of about \$11 million in secondary waste treatment facilities and more than \$4 million annually in operating

costs. This will be important in the immediate future as the industry tools up to meet the standards set under the Federal Water Pollution Control Act. Introduction of dry caustic peeling can reduce prices that the consumer must pay for processed potato products.

Frozen, Quick-Cooking Beans. A process for preparing a variety of quick-cooking (5-15 min.) frozen products from dry Lima, pinto, small white, blackeye and soy beans was developed by Department scientists, supported in part by the California Lima Bean Advisory Board. The cooked beans have an enhanced natural flavor, a smooth uniform texture and excellent appearance. The new products provide consumers with a new type of economical, high protein, convenience foods. Frozen food processors can produce them during their slack season, when plants would otherwise be idle. If the products are produced on demand, warehousing costs can be saved. The frozen bean products will provide opportunities for the development and marketing of convenience foods such as frozen vegetable and soup mixes, and bean-meat casseroles. Pilot plant production of frozen, quick-cooking products from several types of dry beans has been initiated by two leading frozen food processors.

Control of Consistency of Tomato Products. Department scientists have successfully applied fundamental knowledge of enzyme behavior to the problem of controlling the consistency of tomato products. About three-fourths of the processing tomato crop is converted into juice, paste, catsup, or other pureed products in which consistency is an important quality factor. By adjusting the acidity of raw tomatoes during crushing, it is possible to control the activities of two enzymes which govern consistency and to increase the recovery of pectins. This enables the processor to make thick juice, thin juice, firm tomato juice gels (aspic), or products like catsup or sauce with intermediate consistencies. In short, it gives him control over consistency. Many packers of tomato products are greatly interested in these developments and several of the largest companies have research and development programs in progress directed toward application of these findings to their commercial operations.

Is Aflatoxin a Problem in Meat? It is known that the aflatoxins produced by certain molds can cause liver cancers in several animal species. Hazards involved in exposure of meat animals to these toxins have now been evaluated. Swine, cattle, and poultry were fed rations containing graded levels of aflatoxin under practical feeding conditions. Records were kept of growth, mortality, feed consumption, and blood and liver enzyme levels. At slaughter, tissues were subjected to histopathological examination, and meat samples were tested for aflatoxin and toxic residues. Rations containing up to 300 parts per billion had no adverse effects on the animals. No toxic residues were found in the meat from these animals, even at the much higher levels tested.

Improved Pasteurization of Egg Products. Whole egg has been pasteurized successfully for more than 10 years and it was generally assumed that the

conditions used to treat whole egg would be satisfactory for other egg products. However, Department studies showed that the recommended conditions of heat treatment for whole egg are not adequate for yolk, sugared yolk, or salted yolk. To achieve equivalent degrees of safety yolk must be held at a temperature 2° F. higher, and salted or sugared yolk must be held at a temperature 6° F. higher than whole egg during the standard three and one-half minute pasteurization. These findings have led to improved pasteurization practices in the egg industry and revised regulations governing the grading and inspection of egg products. These improved practices assure the adequacy of current egg pasteurization operations for all egg products.

WHEAT UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968			
	Research Problem Area			
	601	406	407	Total
California (Albany)				
Chemical Composition and Physical Properties	3.0	5.0	0	8.0
Flavor	0	4.0	-	4.0
Color, Texture and Other Quality Factors	0	0	-	0
Microbiology and Toxicology	0	3.0	0	3.0
Technology--Process and Product Development	14.6	2.0	2.0	18.6
Total	17.6	14.0	2.0	33.6

Intramural program is supplemented by extramural support representing (a) 1.6 SMY's per year at State Agricultural Experiment Stations^{1/}, (b) 2.4 SMY's per year at other U.S. institutions^{2/}, and (c) P.L. 480 funds in 4 countries representing 54,625 U.S. dollars equivalent per year.

- ^{1/} RPA 601 - Chemical Composition and Physical Properties 1.2 SMY;
Color, Texture and Other Quality Factors 0.4 SMY.
- ^{2/} RPA 406 - Chemical Composition and Physical Properties 0.7 SMY;
Flavor 0.6 SMY; Color, Texture and Other Quality Factors 1.1 SMY.

Problems and Objectives

The dominant feature of the wheat economy in the United States is a production capacity that can outpace consumption. Research on utilization of wheat seeks to solve the problems hindering the development of markets for the full productive capacity of U.S. agriculture. The emphasis is on expanding overseas dollar markets for U.S. wheats; developing new wheat food products for long-term market development in food-short nations abroad; raising the domestic consumption of wheat foods by increased variety, quality, and convenience; finding means to upgrade wheat millfeeds to recover fractions of nutritious food quality; and developing new and improved feeds from wheat.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving baking properties of bread flours by controlled maturation acceptable in European countries.
2. Maximizing utilization of U.S. winter wheats in blends with weaker wheats in European countries.
3. Developing protein-enriched export foods from wheat flours and millfeed fractions and concentrates.
4. Improving quality of continuous-mix baked goods.
5. Improving quality retention in frozen fermented bread doughs.
6. Developing processes to enhance the nutritive value of wheat for ruminant, poultry and swine feeds.

Progress - USDA and Cooperative Programs

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

A. Chemical Composition and Physical Properties

1. Mechanisms of Wheat Flour Maturation. Extraction of lipids from flour with petroleum ether somewhat decreased the amount of hydrogen sulfide released in a subsequent mixing of dough under nitrogen. Treatment with methyl bromide also decreased the subsequent release of hydrogen sulfide. These results suggest that the protein purothionin may have a role in maturing mechanisms.

Under a research grant, the University of Wisconsin is following up observations that peroxidase activity in wheat plant tissues rises following infection with plant pathogens in an attempt to determine the biological

role of peroxidase. The polymerization of proteins caused by peroxidase is also caused by tyrosinase. The polymerization can be induced with poly-lysine and does not seem to involve sulfhydryl groups or disulfide bonds.

Oxidative gelation of wheat-flour pentosans involves an intermolecular cross-linking of the chelate-bridge type of ferulic acid ester groups which can form coordination complexes with adventitious calcium ions. Ligand structures were probably hydroxyquinones. Confirmatory evidence is being sought by The Swiss Federal Institute of Technology, Switzerland, supported by P.L. 480 funds. A kinetic study indicates that oxidation of caffeic acid by peroxidase in the presence of hydrogen peroxide involves the direct introduction of one or more additional hydroxyl groups into the aromatic nucleus, followed by further oxidation to hydroxyquinones.

These studies provide basic information currently needed for improving baking properties of bread flour by controlling maturation.

2. Protein Changes During Malting. Contract research on the changes that occur in wheat proteins during malting has been concluded at the University of Minnesota. Protein Efficiency Ratios (corrected to casein at 2.50) for samples of eight wheat varieties ranged from 0.85 to 1.36 (mean 1.14) in rough inverse correlation with protein content. The PER's for the same wheats malted at 12° and 15° C. were not significantly different from those of starting wheats. Supplementation with lysine at 0.1, 0.2, and 0.3% addition produced an equivalent response in malted and unmalted wheat samples. Test animals showed no preference for either malted or unmalted samples. The animal feeding studies showed that no significant increase in nutritional value of wheat occurs as a result of sprouting (malting); however, these results by no means eliminate the potential of the method as a valuable first step for simplified processing of wheats.

This study provides basic information currently needed for the development of protein enriched export foods from wheat.

B. Flavor (no current research)

C. Color, Texture, and Other Quality Factors

1. Wheat-Bran Pigments. In contract research at Oregon State University, colored substances extracted from red and white brans were found to have more similarities than differences. Benzene or ethanol extracted material containing 3.6 to 7.6% nitrogen from red and white wheat brans. Dioxane-water extracted highly colored material with 3.8 to 12.0% nitrogen and molecular weights of 20,000-50,000. The presence of arginine, aspartic acid, glutamic acid, glycine, leucine, phenylalanine, proline, and threonine indicates a peptide or protein material. Polyphenolic substances also occur. Oxidation of the colored material produced fragments with 2,4- and 3,4-hydroxylated benzoic or cinnamic structures.

This study provides basic information currently needed for the development of protein enriched export foods from wheat.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Modification of Flour and Dough Through Maturation. Studies on the modification of flour and dough components implicated in oxidative improvement of baking performance have been initiated to provide information currently needed to improve baking properties of bread flour by controlling maturation.

2. Blending Capacity of U.S. Winter Wheat. Contract research to determine and quantitate the properties of U.S. hard red winter wheat flours of value in blending with weak flours to obtain optimum baking performance has been concluded. The investigators, Kansas State University, found that when flours of 12-15% protein were blended at a ratio of 1:3 with European wheat flours, definite systematic improvements in quality characteristics were observed. The improvements, per unit of protein, were equally as good with winter as with spring wheat flours. In many cases, hard red winter flours of lower protein content (9.8% and 11.2% in the wheats, 8.6% and 10.1% in the flours) also contributed noticeably to quality improvements. Obviously, the changes could not be expected to be large when added to wheats of similar protein content or in lower proportions. However, variations in test results indicate that improved tests for predicting the behavior of wheats in blends are needed to permit proper selection of wheats for export and their combination with those wheats with which they will perform best.

3. Changes in Flours During Bread Making. Research has been initiated to compare changes produced in specific components of winter and spring wheat flours and doughs by chemical and mechanical treatments simulating those given flours and doughs in bread-making processes as a basis for understanding the preferred positions of spring wheats in export markets.

4. Milk-like Products. The WU-modified Fesca Thin Mash Process to separate protein and starch of wheat flour has been successfully developed on a pilot-plant scale. Separations with a soft wheat flour were excellent over a wide range of conditions. Conditions for acceptable separation with hard red winter wheat flour were more exacting, but attainable. Solubilization of 90% of a flour (including 85% of the protein) was achieved at pH 6 with a new enzyme, Monzyme. The enzyme-treated flour is quite bland, does not coagulate or precipitate at 95° C., and may be used for preparing milk-like or other protein-containing beverages.

5. Heat-moisture Effects on Wheat Constituents. A study of interrelated heat-moisture effects on constituents of wheat and wheat fractions during processing has been initiated. This information is needed for the development of protein-enriched export foods from wheat.

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

A. Chemical Composition and Physical Properties

1. Interaction of Dough Constituents. Insoluble phospholipid-metal-protein complexes formed by addition of phosphatidyl serine and Ca(II) or Ni(II) to water-soluble flour proteins contained all the tyrosine and cysteine and most of the methionine of the proteins. Complexed proteins were more acidic than the non-complexed. Blocking of sulfhydryl groups prevented complex formation most effectively when Ni(II) was the metal ion.

Modified paper electrophoresis techniques separated two acidic peptides from pepsin digests of alpha-gliadin; one fraction contained most of the aspartic acid of alpha-gliadin. This concentration of aspartic acid residues on a small fragment of the alpha-gliadin molecule suggests that charged groups are distributed unevenly on the molecular surface.

Supported by P.L. 480 funds, the Centre National d'Assistance Technique et de Recherche Applique, Antwerp, Belgium, conducted research to determine which isopropanol-soluble proteins or other protein fractions of wheat are most closely related to variations in baking quality. Protein distribution between solvents differs for ground wheat and flour. The gliadin/albumin ratio is higher for flour than for ground wheat. Results with n-butanol demonstrate the importance of lipids. Statistical studies show highly significant coefficients of correlation between sedimentation value and the amounts of proteins extracted with 40% isopropanol and 60% isopropanol. The protein fraction extracted with 40% isopropanol contains 15 to 20 components, separable by electrophoresis on starch gel. The electropherograms vary with origin of wheats, but are not changed by extraction with n-butanol. Separation on a carboxymethyl cellulose column shows the proteins extracted by 40% isopropanol contain a fraction soluble in saline acetic medium (I) and another soluble in pH 11.85 trisodic phosphate (II). The relations between I and II vary with n-butanol treatment and wheat type.

The Flour Milling and Baking Research Association, England, supported by P.L. 480 funds, found no significant difference in the binding of lipid in fat-containing doughs mixed in the same mixer at the same rate of work input to 2 and 6 Wh/lb. respectively. The high degree of scatter involved appears at least in part to be inherent in the process. Work was initiated on the distribution of lipid between gluten, starch, and water-soluble fractions of dough made from Bison (1966) and Cappelle (1966) flours. Purothionin is a mixture of components closely related to the fast moving globulins, and the crude materials contain other proteins with the electrophoretic mobilities of albumins, thus confirming the presence of a range of "proteolipids" in flour. Fractionation of purothionin yielded products each giving a single band on starch gel electrophoresis. The fast moving globulins were fractionated in the same way. Evidence of close similarity between these globulins and purothionins was strengthened by amino acid

analyses "fingerprints" and C-terminal end group determinations. Lipopurothionin has been separated into six components. Phosphatidyl choline, amino phospholipids and two glycolipids were present in the fractions. Preliminary findings have confirmed the inhibition of yeast multiplication by purothionin, but have shown no effect of this compound on gas production in yeasted doughs.

These studies provide basic information currently needed to improve the quality of continuous-mix baked goods.

B. Flavor

1. Bread Flavor. Identity was established for one of two cracker-like aroma components detectable by gas liquid chromatography in extracts of freshly baked bread. Analyses by nuclear magnetic resonance, infrared, and mass spectrometry identified the compound as 1,4,5,6-tetrahydro-2-acetopyridine. A major reaction product of proline and dihydroxyacetone, or other polyhydric compounds, the acetopyridine is stable as the bisulfite complex or as the hydrochloride. When a dilute solution was sprayed onto the crust of a loaf of stale bread, the odor of the crust appeared to become more nearly like that of freshly baked products.

Contract research has been initiated at the Evans Research and Development Corporation, New York, to study the chemical pathways involved in flavor development and deterioration in bread crust and crumb.

These studies provide basic information currently needed to improve the quality of continuous-mix baked goods.

C. Color, Texture, and Other Quality Factors

1. Character of Doughs. In contract research at Stanford Research Institute, California, the response of dough to a small sinusoidally-varying shear strain was studied with a sensitive dynamic rheometer which permits the storage and loss moduli to be determined at frequencies from 0.01 to 200 cycles per second and at peak amplitudes from about 1.5 to 200 microns. (Storage modulus is proportional to the energy stored and recovered per cycle; loss modulus, to the energy dissipated.) Both moduli for dough decrease markedly with an increase in amplitude. Also, when amplitude is changed during a test, about 20 minutes are required before the moduli become constant. Entrapped air (in dough) was not responsible for the amplitude dependence, as doughs mixed in vacuum behaved in the same way. With wet gluten or a 5% gelatin gel in place of dough, no amplitude dependence was shown up to 200 microns displacement. When starch was added to the gluten, amplitude-dependence again was found. Attempts to determine a yield value, indicative of a three-dimensional continuous structure, for dough indicated that if a yield value exists it is extremely small.

Supported by P.L. 480 funds, the Bread Institute of Australia used especially designed equipment to study rheological properties of dough. Tests with

laboratory-milled flours of widely differing characteristics indicated that for a highly filled system such as dough, differences in viscoelastic behavior of the gluten may be minimized so that the behavior of a dough need not necessarily reflect these differences. The influence of starch on viscoelastic behavior of different glutes at various levels of water absorption was studied. Glutes were washed from a strong high-protein flour, a very extensible biscuit flour, a well-balanced bread flour and a flour from a Mexican dwarf wheat variety. Dynamic mechanical properties were determined for various protein-starch-water compositions to study the pseudo-linear region of normal doughs. In addition non-linear behavior of these three-component systems was observed. By computer analysis it appears that parameters that are related to the physical behavior of the material and are free from artifacts arising from the geometry of the cell system may be isolated from non-linear experimental observations obtained at larger deformations.

Supported by P.L. 480 funds, Osaka Women's University, Japan, is investigating the modification of physical properties of doughs and gluten by incorporation of selected polymeric materials. Farinograms of doughs containing selected reduced proteins show an increase in initial consistency after addition of iodate, followed by a prominent weakening, in comparison with farinograms of doughs with the unreduced proteins or cysteine. Extensographs show that sulfhydryl compounds decrease resistance, but the resistance is recovered by the addition of iodate. Reduced polyvinyl thioglycollate, SH-ovalbumin and SH-water soluble wheat protein produced a much more desirable mellowing effect on dough than cysteine did. This effect might be brought about by the association of SH-polymer and gluten through SH-SS exchange reaction. Reduced SH-whey did not produce the same effect.

These studies provide basic information currently needed to improve the quality of continuous-mix baked goods.

D. Microbiology and Toxicology

1. Improved Quality Retention in Frozen Fermented Bread Doughs. Improvements in stability of frozen straight doughs were achieved by (a) addition of 20 to 30 ppm of potassium bromate which serves to improve volume without severely reducing gassing power, (b) selection of commercial source of compressed yeast and (c) storage of compressed yeast at 35° F. for 5 to 7 weeks prior to use, which results in an approximately additional doubling of residual activities. Selection of source of compressed yeast combined with 7-week storage of yeast at 35° F. resulted in reduced proof time, increased residual gassing power, increased residual yeast count and increased bread volume.

Active dried yeast was not as effective as compressed yeast in frozen straight doughs.

E. Technology--Process and Product Development

1. Effects of Starch Components on Quality of Continuous-mix Baked Goods.
A 3-pound batch of flour was separated into protein and starch fractions by the WU-modified Fesca Thin Mash Process. Baking tests on flour reconstituted from the fractions showed no loss of functional properties. When the process was extended to pilot-plant scale composition and yield data indicated no significant differences due to size of batch.

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL
PRODUCTS FROM FIELD CROPS

A. Chemical Composition and Physical Properties

(no current research)

B. Microbiology and Toxicology

(no current research)

C. Technology--Process and Product Development

1. Ruminant Feeds. In vitro tests to evaluate digestibility of processed grains were developed. In vitro digestibility of popped grain was intermediate between raw grain and pressure cooked material. Microscopic studies show that starch is almost completely gelatinized in fully popped grains. A digestibility trial using sheep showed greater improvement for popped milo than for popped barley. Good gains and feed efficiency were obtained for popped milo in other sheep feeding trials.

2. Nonruminant Feeds. Bran mash before and after steam-pelleting has markedly different metabolizable energy values, but only slightly different chemical composition. Biochemical changes such as destruction of residual enzymatic activities also occur during steam pelleting. Steam pelleting causes starch gelatinization, which improves digestibility. Four previously unknown sugars in wheat bran have been found: stachyose, neokestose, fructosyl-raffinose and a tetrafructosyl glucose penta-saccharide.

The lipid and fatty acid content of seven representative samples of U.S. wheats and their millfeeds have been determined.

Publications - USDA and Cooperative Program

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

Chemical Composition and Physical Properties

Neukom, H., Proivoli, L., Gremler, H., and Hui, P. A. 1967. Recent Investigations on wheat flour pentosans. Cereal Chemistry 44:3. ^{1/}

Neukom, H., Geissmann, T., and Painter, T. J. 1967. New aspects of the functions and properties of the soluble wheat-flour pentosans. Bakers Digest 41(5):52-55.

Technology--Process and Product Development

Senti, F. R., Copley, M. J., and Pence, J. W. 1967. Protein-fortified grain products for world use. Cereal Science Today 12:426-430, 441.

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Chemical Composition and Physical Properties

Bernardin, J. E. and Kasarda, D. D. 1967. Ultraviolet fluorescence and absorption changes accompanying reversible aggregation of alpha-gliadin. Federation Proc. 26:820.

Fullington, J. G. 1967. Interaction of phospholipid-metal complexes with water-soluble wheat protein. J. Lipid Research 8:609-614.

Nimmo, C. C. and O'Sullivan, Mary T. 1967. Immunochemical comparisons of antigenic proteins of durum and hard red spring wheats. Cereal Chem. 44:584-591.

Nimmo, C. C., O'Sullivan, Mary T., and Bernardin, J. E. 1968. The relation of a "globulin" component of wheat flour to purothionin. Cereal Chem. 45:28-36.

Color, Texture, and Other Quality Factors

Tanaka, Kenji, Furukawa, Kazuyo, and Matsumoto, Hiroshi. 1967. The effect of organic and inorganic acids on the physical properties of dough. J. Ferment. Technol. 45:566-569. ^{1/}

Tanaka, K., Furukawa, Kazuyo, and Matsumoto, H. 1967. The effect of acid and salt on the farinogram and extensogram of dough. Cereal Chem. 44:6^{1/}

^{1/} Research supported by P.L. 480 funds.

RICE UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	:	Scientist Man-Years F.Y. 1968	:
	:	Research Problem Area	:
	:	406	: Total
California (Albany)	:		:
Technology--Process and Product	:		:
Development	:	2.0	: 2.0
Total	:	2.0	: 2.0

Intramural program is supplemented by extramural support representing (a) 0.7 SMY's per year at State Agricultural Experiment Stations^{1/}, (b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds in 1 country representing 12,575 U.S. dollars equivalent per year.

^{1/} RPA 406 - Technology--Process and Product Development 0.7 SMY.

Problems and Objectives

The per capita consumption of rice in the U.S. has increased about 25% over the past ten years. Most of the increase has occurred through the use of processed products featuring convenience of use, especially quick cooking rice. Most of this product is made by processes which are inefficient due to rather large losses of solubilized solids and to kernel breakage. Final product cost is therefore higher than necessary. Also all precooked rice is made from long-grain rice, which is higher in cost than medium- or short-grain rices. The need is for new and improved food products with better nutritive quality and produced at minimum increase in cost. Such products must be easy to prepare; have good texture, flavor, and appearance; and be economical to manufacture. Also needed are drastically improved milling methods.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing new processing methods and lower cost consumer products from short- and medium-grain rices.

Progress - USDA and Cooperative Programs

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

A. Chemical Composition and Physical Properties

1. Amylopectins of Rice. The Nagoya University, Japan, supported by P.L. 480 funds, is conducting research to determine the biochemical and physical factors in the structure of amylopectic molecules of rice starch as they relate to processing characteristics. Two major enzymic pathways appear to operate in the breakdown of carbohydrate reserve in germinating rice seeds. One is the phosphorylytic cleavage of polysaccharide (starch) by the starch phosphorylase and the other is the hydrolytic breakdown through the amylolytic enzymes (alpha- and beta-amylases). Maltose-series oligosaccharides are hardly detectable in nature; this fact casts some doubt on the second alternative in germination processes. Analysis of phosphorylase activity was initiated and evidence of phosphorylase reaction in germinating rice seeds was found. Quantitative analysis of carbohydrates indicated existence of appreciable amounts of maltose-series oligosaccharides; this suggests the existence of amylolytic breakdown of reserve polysaccharides. Studies of the functions of alpha-glucosidase and maltase were initiated. Gibberellic acid-treated rice seeds did not show marked change in carbohydrate metabolism when compared with untreated rice seeds. Adenolate protection of rice granular starch synthetase against iodoacetate inhibition was studied. Evidence suggests that the iodoacetate binds to histidine residues residing in the enzyme active site.

B. Flavor (no current research)

C. Color, Texture and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. New Rice Products. Amino acid analyses of 25 samples of rices and milling byproducts showed similar compositions for all samples of each type (rice, bran, millfeed), and appreciable differences between types, as expected. Gel filtration and electrophoresis showed that a segregated major fraction of milled rice albumins is comprised of two components with similar molecular weight. Bran albumins contain more components, each in smaller proportion. Globulins of regular and waxy rice have identical components. Information obtained in this investigation is needed for evaluating potential food uses of the various products.

2. High-protein Rice Products. The University of California in Berkeley is conducting contract research to evaluate the cooking and processing characteristics, utility of new products, and optimum economic balance of products from white rice overmilled to various degrees. Three flours totaling 8 to 15% of the total kernels by weight were prepared by abrasively milling three consecutive surface layers from each of six varieties of milled rice. Completed analyses on the flours and on original and residual kernels include moisture, ash, protein, fat, phytic acid, and riboflavin. Cooking evaluations were made on original kernels and those remaining after each milling. Nutritive values of flours and original and residual kernels were determined by rat-feeding tests and as Protein Efficiency Ratios.

Publications - USDA and Cooperative Program

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

Ferrel, R. E. 1968. Coated Rice. U.S. Patent No. 3,384,493.

Houston, D. F. 1967. High-protein flour can be made from all types of milled rice. Rice J. 70:12-15.

Huxsoll, C. C. and Morgan, A. I., Jr. 1968. Microwaves for quick-cooking rice. Cereal Sci. Today 13:203-06.

FORAGE UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968		
	Research Problem Area :		
	407	601	Total
California (Albany)			
Chemical Composition and Physical Properties	1.6	-	1.6
Technology--Process and Product Development	4.1	2.5	6.6
Total	5.7	2.5	8.2

Intramural program is supplemented by extramural support representing
 (a) 0.8 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
 in 2 countries representing 91,361 U.S. dollars equivalent per year.

^{1/} RPA 407 - Technology--Process and Product Development 0.8 SMY.

Problems and Objectives

The demand for livestock in the United States will increase 45% by 1975. Since forage crops constitute the major feedstuff for ruminant animals, the demand for forages will increase accordingly. In addition, there is an increasing demand for processed forages in European and Asiatic markets as well as in domestic markets. Fresh forage crops are the richest natural source of many nutrients for farm animals. However, up to 30-40% of the forages are lost during haymaking and ensiling. Dehydration is now the only practical means of producing products of high nutritional value in a form usable in manufactured feeds and supplements, but use of dehydrated products is restricted because of their high-fiber and growth-inhibitor content. New and improved products are needed for foreign and domestic markets.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving feeds from alfalfa and other forage crops.
2. Improving ruminant feeds from highly lignified fibrous agricultural materials.
3. Developing new low-fiber products from forage crops for export markets.

Progress - USDA and Cooperative Programs

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL PRODUCTS FROM FIELD CROPS

A. Chemical Composition and Physical Properties

1. Unidentified Growth Factor(s). Research on unidentified growth factors in alfalfa which stimulate the growth of guinea pigs is conducted in cooperation with the University of California, Berkeley. Fractionation studies indicate that the guinea pig unidentified growth factor(s) in alfalfa is soluble in alcohol and other polar solvents. It may be precipitated from an alcohol extract by addition of acetone. Ion exchange separation of the active acetone precipitate left most of the activity in the acid fraction. Recombination of all fractions gave a growth response no greater than that of the acid fraction alone. The growth of animals on the acid fraction was better than that of animals fed the basal diet, but not as good as that of animals fed 10% dehydrated alfalfa meal. The fractionation studies for unidentified growth factors in an aqueous extract of fresh alfalfa with a microbiological assay using Bacillus subtilis has been completed. Adenine, adenosine, hypoxanthine, and guanosine stimulated growth of the organism.

B. Microbiology and Toxicology (no current research)

C. Technology--Process and Product Development

1. Improved Forage Products. Research on leaf-stem separation by air classification of unground dehydrated alfalfa has progressed through the pilot plant to full plant scale studies. Pilot plant and commercial plant studies have shown that losses of xanthophylls during dehydration are inversely correlated with moisture content at the discharge end of the dehydrator.

Cooperative research with the Economic Research Service has resulted in a powerful computer technique, parametric linear programming, to determine intrinsic values of experimental products and to guide process research.

A full knowledge of valuable components is necessary to evaluate the products developed from forages. Stachydrine determinations are being made on forages and feeds other than alfalfa. The major quaternary compound in all feeds tested other than alfalfa is betaine rather than stachydrine.

Pilot-scale tests of a dry process for alfalfa leaf-stem dehydration and separation produced over 300 tons of products, which are being evaluated chemically and biologically by several university and industry laboratories. Two companies are using the process.

2. Alfalfa Products. In contract research at the University of Nebraska, basic data on alfalfa stem digestion have been obtained from feeding alfalfa leaf-stem mixtures to sheep. In vivo improvements of digestibility of stems treated chemically were not as large as anticipated from in vitro assays. In vitro tests showed alfalfa lignin to be more resistant to breakdown than cereal straw lignin. Treatment of stems with steam has been carried out at pressures up to 600 psi, but over 300 psi there were no increased benefits. About 700 samples have been treated and assayed by the in vitro method. Some studies have been made on stem material combining chemical treatment with high pressure-high temperature. A lamb digestion trial using high pressure cooked material showed increased carbohydrate digestibility but decreased protein digestibility.

3. Products from Southeastern Grasses. Contract research at the University of Georgia has been concluded. Conditions necessary for the consistent production of high-quality dehydrated Coastal Bermuda grass and pearl millet were established. Carotene and xanthophyll levels were higher than in standard alfalfa meal. Carotenoid stability during storage was similar to alfalfa and similarly enhanced by ethoxyquin. Metabolizable energy for the growing chick was 1400 Kcal/kg. Xanthophyll in the grasses was equal in biological value to that in dehydrated alfalfa meal and corn gluten meal. The proximate analyses, vitamin content, amino acid composition, and mineral content for the dehydrated grasses were determined, and would be useful in computer least cost feed determination. Processing costs for dehydrating these grasses are higher than for alfalfa, but for sale in Southeastern states, this is offset by lower transportation costs.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

A. Chemical Composition and Physical Properties

Information obtained in the following investigations provides the basis for the development of products from forage crops.

1. Estrogen Inhibitors. Supported by P.L. 480 funds, The Hebrew University, Israel, has initiated an investigation of the nature of the estrogen-inhibiting factors in alfalfa and other forages.

2. Alfalfa Saponins. Supported by P.L. 480 funds, The Hebrew University, Israel, is also studying the saponin components of alfalfa. At least nine different saponin fractions were separated from alfalfa tops and roots. A close resemblance was found between alfalfa top saponin and root saponin prepared by the same method and compared by thin-layer chromatographic separation. Hemolytic indices showed remarkably greater activity for the root saponin than from that of the alfalfa tops. Foam forming activity also differed. Soyasapogenin E was found in alfalfa, a fact that had not been previously reported. Alfalfa top saponin was harmless to Tribolium castaneum larvae while the root saponin was highly toxic. Addition of cholesterol to the diet almost completely overcame the toxic effects of the root saponin.

3. Natural Alfalfa Antioxidants. Research supported by P.L. 480 funds at The Experiment Station for Practical Agriculture in Milano, Italy, has been concluded. Natural antioxidants isolated from alfalfa include alpha-tocopherol, solanachromene and an unidentified compound RD₂. Solanachromene has a lower antioxidant activity in protecting beta-carotene in inert medium than alpha-tocopherol while compound RD₂ possesses greater activity. In dried alfalfa samples incubated at 37° C. for 46 days, the alpha-tocopherol and solanachromene do not appear to have retained protective efficiency while weak activity was still observed for compound RD₂.

B. Microbiology and Toxicology (no current research)

C. Technology--Process and Product Development*

1. Improved Forage Feed Crops. Promising results have been obtained in preliminary small-scale tests of a separation process for fresh forage. Smooth juicing rolls removed about 45% of the weight of fresh alfalfa. The juice contained 10% solids and was rich in protein, xanthophyll, carotene, minerals and vitamins. A continuous vat process separated the protein from the juice after heat coagulation. The protein coagulum can be skimmed off from the juice, eliminating the need for expensive centrifuging equipment. The material, dried by lyophilization, contained essentially no fiber and more than twice as much protein, carotene, and xanthophyll than good quality dehydrated alfalfa.

* This research also has importance for RPA 407.

Publications - USDA and Cooperative Program

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL
PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

Guggolz, J., Herring, V. V. and Kohler, G. O. 1967. Dehydrated alfalfa composition. Correlation of Non-nutrient components with protein content. Agr. and Food Chem. 15:1052.

Livingston, A. L., Knowles, R. E., Nelson, J. W., and Kohler, G. O. 1968. Xanthophyll loss during pilot and industrial scale alfalfa processing. Agr. and Food Chem. 16:84.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

Chemical Composition and Physical Properties

Polesello, A. 1967. The natural antioxidants in the preservation of dehydrated alfalfa. Studi in Onore Di Ugo Pratolongo, Vol. XI della Collana della rivista Agrochimica.^{1/}

Technology--Process and Product Development

Taylor, Reed D., Kohler, George O., Maddy, Kenneth H., and Enochian, Robert V. 1968. Alfalfa meal in poultry feeds--an economic evaluation using parametric linear programming. Agricultural Economic Report No. 130.

^{1/} Research supported by P.L. 480 funds.

WOOL AND MOHAIR UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968	
	Research Problem Area :	
	411	Total
California (Albany)		
Chemical and Physical Investigations to Improve Products	16.0	16.0
Technology--Process and Product Development	20.2	20.2
Total	36.2	36.2

Intramural program is supplemented by extramural support representing (a) 0.7 SMY's per year at State Agricultural Experiment Stations^{1/}, (b) 0.8 SMY's per year at other U.S. institutions,^{2/} and (c) P.L. 480 funds in 4 countries representing 101,485 U.S. dollars equivalent per year.

1/ RPA 411 - Technology--Process and Product Development 0.7 SMY.

2/ RPA 411 - Technology--Process and Product Development 0.8 SMY.

Problems and Objectives

Traditional markets for wool and mohair have been lost to synthetic fibers because consumers prefer garments that hold their pleats and creases, resist shrinkage and wrinkling during washing, and dry quickly. Natural wool and mohair outclass the synthetics in tailorability, comfort in wear, appearance, and hand, but lack certain features now being exploited by the promoters of synthetics. Furthermore, some current processing methods damage, distort, or weaken wool and mohair fibers and injure performance and appearance of the fabric. We need processes that will modify natural fibers to give a range of comfortable and attractive fabrics that resist deterioration in processing and wear. New markets in industrial and other uses would develop for new types of fabrics, woven and non-woven, made from natural wools and from blends of wool with modified wools or other fibers.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing improved durable-press wool and mohair garments.
2. Improving efficiencies in the processing of worsted wool and mohair yarns.
3. Developing treatments for wool and mohair products to decrease upkeep costs.

Progress - USDA and Cooperative Programs

RPA 411 - NEW AND IMPROVED PRODUCTS FROM WOOL,
HIDES, SKIN AND ANIMAL FATS

A. Chemical Composition, Physical Properties and Structure

(no current research)

B. Chemical and Physical Investigations to Improve Products

1. Effects of Physical and Chemical Structures. Research conducted to relate fundamental fiber structure to fiber properties provides information needed to improve efficiencies in the processing of worsted wool and mohair yarns. A detailed molecular formulation of the relaxation processes from the glassy through the rubbery stages in amorphous large molecules has been completed.

Wear tests of double knit wool/cotton blend fabrics were undertaken with women's slacks as the test garments. Two series of fabrics were studied: (1) wool top was shrink-resist treated prior to blending, and (2) the blended fabric was shrink-resist treated. Dyeing and durable-press treatment were the same for both sets of fabrics. After an average of ten

washings with two to three days wear between washings, slacks made from the blend treated fabrics had better wear appearance retention than those made from the top treated samples. Surface smoothness was the same for both samples. Blends with higher cotton content retained the crease better and developed less fuzziness, but blend ratios did not affect surface smoothness. Fabrics with higher wool content had better color appearance and a more wooly hand.

2. Easy-care Treatments. Reaction of dimethyloldihydroxyethylene urea (DMDHEU) with wool eliminated supercontraction, decreased alkali solubility, reduced Van Slyke nitrogen and reduced break strength and flex abrasion, but did not affect wrinkle recovery or flexural rigidity. Water soluble cellulose were crosslinked to wool with DMDHEU.

New methods of graft polymerization to wool were discovered: (1) reacting the polymerization catalyst with the wool surface insured grafting to the wool and (2) using the wool surface as a component of a redox system with H_2O_2 also effected grafting. Treatment of polyacrylic acid grafted wool with metallic carbonates or hydroxides made the wool shrinkproof; some treated samples actually expanded on washing.

Dye-sensitized photopolymerization was successfully carried out on wool, mohair and fibroin fibers. When wool was treated with epoxides to introduce additional hydroxyl groups and then with DMDHEU, no significant increase in crosslinking was found.

A study of polymer surface energy and oil repellency of polymer-coated wool fabric led to the finding that the critical surface tension of wetting for a polymer does not necessarily reflect its ability to act as an oil repellent when applied to wool. A low-cost, superior oil and water repellent fluorochemical finish for wool is possible through proper positioning of the fluorine atoms in the fluorochemical along with appropriate formulation of the finish with a low-cost nonfluorinated diluent.

3. Molecular Processes. Supported by P.L. 480 funds, the University of Allahabad, India, is studying the interactions of organic molecules within wool fibers. Information obtained in this investigation is needed to develop improved efficiencies in the processing of worsted wool and mohair yarns. Earlier studies indicating the existence of glycerol-water complexes with ratios of 1:6 and 1:1 were confirmed. Complexes with ratios of 4:1 and 1:4 were detected in mixtures of glycerol and dioxane. Glycerol and dioxane which are normally immiscible are mixed with the help of a known quantity of water which acts as an inert solvent as far as the observed excess absorption peaks are concerned.

4. Adsorption of Selected Ions. The Ahmedabad Textile Industries Research Association in India, supported by P.L. 480 funds, is measuring the adsorption energy of selected ions to wool in order to determine the accessibility of ion exchange sites as loci for chemical modification. This information

will be helpful in efforts to improve efficiencies in the processing of worsted wool and mohair yarns. The adsorption of various inorganic ions onto wool fiber was studied by using three different types of wool and 0.05N solutions of sodium chloride, sodium sulfate and sodium phosphate. Different types of wool behave similarly on adsorption of sodium and chloride ions onto the wool fiber in the isoelectric region. The internal volume term has a significant value when evaluated from the distribution study of uni-univalent, unibivalent and unitrivalent electrolytes only when these electrolytes are treated as sodium salts of a monobasic acid.

5. Chemical Effects on Fiber Crimp Stability. The Institute for Fibres and Forest Products Research in Israel, supported by P.L. 480 funds, is conducting research to relate fiber crimp to chemical, physical, and mechanical properties of wool and determine the effects of processing on crimp. Dynamic and static crimp parameters were obtained for three standard U.S. wools, five South African Merino wools and several low crimped wools from other breeds. Linear relationships were found between crimp diameter and cross-sectional area. Crimp diameter was smaller for finer wools. Crimp diameter decreases with increasing stress in a linear manner and data were related to mechanical properties such as bending moment or torsional rigidity of fibers. Uncrimping energies and stresses were related to each other but neither were found related to Young's Modulus. Thus low extension properties of the fiber are not necessarily related to elastic properties at higher extensions. Correlations were found between feltability and uncrimping energy or uncrimping force with the higher uncrimping parameters associated with lower feltability. Feltability was not related to fineness except for the U.S. standard wools where finer wools felted more readily than coarser. When an additional crimp was set into fibers of low crimped wools the differences in amount of set crimp retained suggest that native molecular structure is involved in determining the final amount of set crimp.

6. X-ray Diffraction Patterns. The German Wool Research Institute in Aachen, West Germany, is supported by P.L. 480 funds to correlate chemical and physical properties of various wools with X-ray diffraction measurements. Results of this investigation will help efforts to improve efficiencies in the processing of worsted wool and mohair yarns. The axial periodicity of 39 Å for lysine residues in the structural units of mohair has been confirmed. Attempts to determine the spacings of the tyrosine residues and the carboxy groups of the glutamic acid and aspartic acid have not been conclusive. When tyrosine residues of mohair were nitrated with tetranitromethane, a nearly unchanged X-ray diagram resulted. Detergent treated mohair samples gave totally changed X-ray diagrams. There appears to be an oriented deposition of the detergent molecules along the fiber axis.

7. Sulfur in Wool Keratins. Supported by P.L. 480 funds, the Karolinska Institute in Stockholm, Sweden, is investigating the distribution of sulfur in wool keratin to provide information needed to guide development of improved efficiencies in the processing of worsted wool and mohair yarns.

A study of the pattern and kinetics of incorporation of cystine into hair as well-defined models of wool confirmed that sulfur comes into the hair from the side rather than through the base of the follicle. Preliminary studies of the aggregation of filaments within filament bundles obtained from hair and wool roots suggest that there might exist a preferred type of filament aggregation, namely a right-handed cylindrohelical lattice of filaments.

C. Technology--Process and Product Development

1. Blends of Modified Wools and Cottons. Evaluation has been completed on double-knit fabrics of blended wool and cotton (50/50, 60/40, 70/30, and 80/20) that had been WURLAN shrink-resist treated and durable-press treated with dimethyloldihydroxyethylene urea (DMDHEU). Both WURLAN-treated top and WURLAN-treated blend fabrics were evaluated. Top treated blends had poorer spinnability and knittability than corresponding untreated blends. All blends after treatment had excellent hand. For satisfactory durable press performance, at least 40% cotton is required. In wear tests, WURLAN-treated top samples had a pronounced tendency to develop fuzz and a sleazy appearance, whereas the WURLAN-treated fabric samples had excellent wear appearance retention and retained a crisp handle. Top treated fabrics also had greater shrinkage after washing.

2. Interfacially Applied Resins. Over 6,000 yards of fabric were treated in plant trials of the WURLAN polyurea process for shrink-resist treatment of wool fabric. The experimental run showed that the polyurea process is technologically superior to the commercial polyamide process. Advantages include superior shrink-resist effectiveness, aesthetics, bath stability, simplicity of operation and control, non-corrosiveness, dyeability of treated fabric, and lower cost. Napped blankets made from polyurea-treated material had superior strength and loft when compared with oxidative shrink-resist treated products.

3. Wool/Cotton Fiber Blends. Contract research has been initiated at the Texas Technological College to conduct a study of blending wool/cotton fibers on the cotton processing system.

4. Yarn and Weave Types in Modified Wools. Worsted double-knit samples knitted from high-level WURLAN-treated top showed less than 5x5% shrinkage after ten washing and tumble drying cycles. This shrinkage is well within the limits set by International Wool Secretariat (IWS) Woolmark specifications for washability in wool knits. Loosely constructed samples knitted from lower-level WURLAN-treated top had some felting shrinkage after wash testing. However, the effects of loop length and yarn twist have been shown to be less important than had been suggested by other workers.

A quick method for approximating woven worsted fabric weights for a given warp-filling combination or for determining yarn size required for a fabric weight has been derived. Data published in the form of graphs should be a practical aid to worsted designers.

A computer program that takes typical knitting machine parameters, yarn properties, and needle styles, and simulates the actual knitting operation in terms of maximum tensions occurring in the knitting zone has been derived. From computerized analysis of cam angles, new cam shapes that will reduce knitting tensions have been suggested.

5. Ozone and Electrical Discharge Treatments. Wool top was corona treated under a wide variety of conditions and then evaluated for shrinkage. The most promising lots were spun into yarn and knitted into fabric. Yarn spinnability increased, no doubt due to increased yarn tensile strength. Shrink resistance increased, equivalent to that obtained with other oxidative shrink-resist processes. The pilot scale corona reactor was capable of treating mohair top and mohair raw stock, as well as wool top. Plans and specifications for this reactor are being made available to textile firms interested in production of corona treated wool top. Corona treated mohair had diminished yarn hairiness and improved spinnability and carding properties.

6. High Energy Radiation of Wool. Contract research at the Research Triangle Institute, North Carolina, on the effects of high energy radiation on chemical modification of wool has been concluded. To get a high degree of grafting it is necessary to use a solvent that swells the wool fibers. Formic acid is especially effective; water and methanol are also effective. Only slight changes were found in fiber mechanical properties until grafting was greater than 150% of the weight of the wool. When 3000% of ethyl acrylate was grafted to wool, the fibers had a rubbery appearance and were extremely elastic.

7. Synergism Between Repellents. Harris Research Laboratories, Washington, D.C., is conducting contract research on the synergism between fluorocarbon oil/water repellents and hydrocarbon water repellents. The critical surface tensions of wetting (CST) of mixtures of poly(1-perfluorooctanoyl) aziridine/ or poly(heptafluoro-isopropoxypropylsiloxane) and four non-fluorinated diluents were determined. The diluents were behenamide, polyethylene, a polyurethane and poly(dimethyl siloxane). CST measurements were made on fine glass rods and mohair fibers coated with the mixtures. The fluorochemical-diluent mixtures produced similar low-energy surfaces on the glass and mohair. Small amounts of either fluorochemical produced low CST's but the fluorosiloxane was more effective. With behenamide, either 1.5% fluorosiloxane or 4.4% fluoroaziridine was required to obtain a CST of 17.5 dynes/cm, the value at which surfaces would not be wetted by most oils. Of the three fluorochemicals examined to date, poly(1,1-dihydroperfluorooctyl acrylate) was the most effective in producing low energy surfaces.

Publications - USDA and Cooperative Program

RPA 411 - NEW AND IMPROVED PRODUCTS FROM WOOL,
HIDES, SKIN AND ANIMAL FATS

Chemical and Physical Investigations to Improve Products

- Heidemann, G. and Halboth, H. 1967. X-ray evidence of regularly distributed lysine in alpha-keratin. Nature 213:71-72. 1/
- Pittman, Allen G. 1968. Significant surface properties of new fluoro-polymers. ACS Vortex 29:52-59.
- Pittman, A. G. and Wasley, W. L. 1967. Fluoroalkyl siloxanes as oil and water repellents for wool. American Dyestuff Reporter 56:808-809.
- Singh, R. P., Darbari, G. S. and Verma, G. S. 1966. Acoustical behavior of critical mixtures. Physical Review Letters Vol. 16. 1/
- Singh, R. P., Darbari, G. S. and Verma, G. S. 1967. Derivation of molecular relaxation parameters of an isomeric relaxation. Journal of Chemical Physics 46:151-153. 1/
- Spei, N., Heidemann, G., and Halboth, H. 1968. Further X-ray evidence of regularly distributed lysine in alpha-keratin. Nature 217:247. 1/

Technology--Process and Product Development

- Knapton, James J. F. 1967. The geometry and dimensional properties of weft-knitted fabrics constructions. Knitted Outerwear Times 36:48.
- Morgan, James P. 1967. A novel approach to washable stretch wool fabrics. Amer. Dyestuff Reporter 56:17.
- Russell, Harold W., O'Connell, R. A., and Bartulovich, J. J. 1968. Quick worsted weights. Textile Industries 132:69.
- Thorsen, W. J. and Kodani, R. Y. 1967. Continuous shrink-resist treatment of wool fabric with ozone. Text. Res. Journal 37:975.

1/ Research supported by P.L. 480 funds.

CITRUS AND SUBTROPICAL FRUIT UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968		
	Research Problem Area :		
	403	901	Total
California (Albany)	:	:	:
Flavor	2.0	-	2.0
Technology--Process and Product Development	1.2	1.0	2.2
California (Pasadena)	:	:	:
Flavor	2.0	-	2.0
Color, Texture and Other Quality Factors	3.7	-	3.7
Technology--Process and Product Development	2.3	-	2.3
Hawaii (Honolulu)	:	:	:
Technology--Process and Product Development	2.0	-	2.0
Total	13.2	1.0	14.2

Intramural program is supplemented by extramural support representing (a) 0.9 SMY's per year at State Agricultural Experiment Stations.^{1/}

^{1/} RPA 403 - Color, Texture and Other Quality Factors 0.3 SMY.

Problems and Objectives

The economic stability of the citrus and subtropical fruit industries in the Western Region is dependent upon effective utilization of fruit that cannot be accommodated on the fresh fruit market. Ineffective utilization of products is continuously increasing processing costs and resulting in decreased returns to the grower. Also, deterioration of flavor and color in processed citrus and subtropical fruit products imposes severe limitations upon the economic stability of the industry. New and improved fruit products are needed. The reduction of water pollution is another critical problem for the fruit processing industry. Needed are methods for processing brines so as to reduce the effluent salt contents of processing plants.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving stability and flavor of non-frozen fruit juice concentrates and purees.
2. Developing citrus products with improved flavor and color stability.
3. Processing mechanically harvested dates.
4. Developing sweeteners from citrus constituents.
5. Recovering processing brines for reuse to reduce pollution.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor

1. Quality and Stability of Fruit Concentrates and Purees. The modified WURVAC process for recovering volatile flavors has been thoroughly tested with apple and orange juices. Analyses show that 60 to 70% of the aroma compounds in the feed are recovered. Commercial orange essence has been concentrated as much as tenfold in preliminary experiments using liquid carbon dioxide extraction. Almost all significant aroma compounds in orange essence are easily extracted by liquid carbon dioxide, with the orange oil compounds extracted most easily. Optimum conditions for maximum essence concentration have not yet been determined. Two components resulting from the photolysis of nootkatone have been identified. One is an unusual dihydronootkatone; the other compound is the result of an unusual intramolecular cyclization.

2. Flavonoid Chemistry of Citrus. Several phenolic glucosides were prepared by partial enzymatic hydrolysis of corresponding rhamnoglucosides. Naringinase was partially deactivated by controlled pH and temperature conditions so that the glucosidase activity was lost while the rhamnosidase activity was retained. With partially deactivated enzymes good yields of hesperetin 7-glucoside, prunin and phloracetophenone 4'-glucoside were obtained. In addition, hesperetin dihydrochalcone glucoside was prepared in 50% yield based on hesperidin using the new enzymatic hydrolysis. This compound which offers promise as a commercial sweetener can thus be obtained in better yield and more conveniently than by acid hydrolysis.

Detailed structure analysis of vicienin and di-C-glycosyldiosmetin provided the first such analysis of this type of flavone.

Zapoterin was shown to be a C₂₆ limonoid, 12- α -hydroxyobacunone. 7- α -obacunol was found to be naturally occurring. This is the first discovery of a 7-hydroxy limonoid in the Rutaceae, although 7-hydroxy limonoid derivatives are common in the Meliaceae.

C. Color, Texture, and Other Quality Factors

1. Citrus Color and Bitterness. Limonoic acid A-lactone (a limonin A-ring monolactone) was specifically identified as the nonbitter precursor of bitter dilactone triterpenoid, limonin. The nonbitter compound which is present in navel orange tissues is converted to limonin during juice processing and results in bitterness.

Semi-beta-carotenone and beta-carotenone were structurally identified as the deep red pigments isolated from the fruit of citrus relatives Murraya exotica and Triphosia trifolia. Semi-beta-carotenone is also detected in stored lemons which exhibit a bronzed discoloration.

Lemon, orange, and grapefruit juices have been analyzed for nucleic acids and phospholipids. Essentially all the phosphorus contained in these juices was accounted for in the following fractions: inorganic P, lipid P, small-molecular-weight organic P, nucleic acid P, and protein P. Detailed phosphorus composition will aid in establishing authenticity of citrus fruit juices.

2. Chemical and Physical Factors Affecting Quality of Mechanically Harvested Dates. Separated tissues of grade-classified dates were examined before and after treatments designed to soften the fruit. The inner mesocarp of number 1 dry date has a lower ratio of reducing to non-reducing sugars than other tissues studied, suggesting that inversion starts later or proceeds slower in the inner mesocarp. An assumption is made that inversion is important during post-harvest softening and that hydration is necessary for inversion. Therefore, hydration procedures should be sought that will effectively deliver moisture to the inner mesocarp tissue. Number 1 dry dates were incubated after vacuum infiltration

with water. At 35° C. considerable cell wall breakage or dissolution had occurred in 4 hours, and the condition increased with time through 24 hours. The tissue became similar to that of natural dates. Shear force data suggested that the incubated number 1 dry dates were as soft as natural dates by the end of 4 to 7 hours but histological studies indicated that cell walls were not similar to those of natural dates until a longer period of incubation had transpired. Observations on number 1 and number 2 dry dates support the idea that these dates are immature at a time when moisture is lost too rapidly for ripening to occur. This contract research is conducted at the University of California at Riverside.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Tropical Fruit Products. Mangos were processed to puree and canned and frozen slices. Heat treatment sufficient to inactivate catalase renders mango puree more stable during freezing storage. Nectars made from the puree of unpeeled mangos were preferred to those made from peeled fruit. Blanching before freezing in syrup yielded a mango product that was preferred to unblanched controls.

Guava puree in freezer storage had remarkable stability for 9 months. Heat treatment to inactivate enzymes, deaeration, or both treatments failed to improve aroma or flavor when compared with no heat treatment. Sensory evaluation of nectars failed to distinguish between acid and sweet guavas. Guava puree concentrate was irradiated in a gamma ray source at various levels up to 1000 krad and the effect on stability and quality noted. Microbial cell count on the inoculated pack was reduced in roughly linear fashion with increasing dosage. Spoilage occurred in all samples but rate of spoilage was reduced by irradiation. Temperature of storage had a greater effect than irradiation. No substantial change in color was seen.

2. Lemon Oil Stability. Qualitative studies have demonstrated the presence of a large number of components in commercial lemon peel oil. Little attention had been given to relative proportions or influence of individual components on quality and stability of oil. Procedures are being developed to permit quantitative estimation of various components. Major chemical groupings of lemon oil are being fractionated and tests developed to estimate individual members of homologous groups of compounds.

3. Methods for Processing Mechanically Harvested Dates. Simple methods have been developed to effect a moderately good sort of mechanically harvested dates into maturity classes. These methods are based on size and resiliency of the dates.

Excellent progress has been made in processing various classes of mechanically harvested dates to salable condition. Immature dates can be ripened by freezing to rupture cells and release enzymes, followed by

tempering at refrigerator temperatures first and further tempering and drying at 90 to 100° F. Over-dry dates, partially mature, can be ripened by rehydrating them to the proper moisture level, followed by 24 hours of tempering at 100° F. The processed dates develop an excellent color and texture.

4. Desert Grapefruit Products. Extending previous research on blends of grapefruit juice with juices and purees of other fruits and berries, studies were initiated on color and flavor stability of grapefruit juice products containing strawberry and raspberry juice. In contract research conducted at the University of Arizona in Tucson a method for measuring color stability was developed. Effects of container type, storage temperature and additives on stability of grapefruit drinks containing raspberry and strawberry juice are being investigated. Mid-season desert grapefruit juice of low bitterness when blended with peach and apricot purees was highly acceptable to consumer test panels. Consumer ratings of such blends made with early-season grapefruit, which is more bitter, indicate that grapefruit juice of relatively high solids and low bitterness is necessary for good acceptance.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

A. Chemical Composition and Physical Properties (no current research)

B. Flavor (no current research)

C. Color, Texture, and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Simplifying Disposal of Food Processing Wastes. Plans were drawn for a commercial-scale unit for the recovery of olive storage brine by passage through a charcoal column and made available to the National Cannery Association. The Research Foundation of the National Cannery Association was awarded a demonstration grant by the Federal Water Pollution Control Administration, partially supported by the California olive industry to study reconditioning of food processing brines. Initially, olive storage and processing brines will be used in the commercial-scale unit and their reuse potential evaluated. Scientists from the Western Utilization Research and Development Division will participate as consultants in this project.

In contract research, the National Cannery Association found that small-sized Mission olives can be stored for six months in propylene glycol-diethyl pyrocarbonate or glycol-benzoic acid-sorbic acid mixtures. Shriveling that occurs during storage in glycol-bacteriostat systems is removed after soaking with water and curing with potassium hydroxide solutions. Salt level in olives stored in ammonium sulfate brine can be reduced by treatment with potassium hydroxide solutions. Ammonium sulfate level is reduced very

slowly by all types of washing procedures. Long-term aeration of olives in potassium carbonate suspension facilitates the development of dark skin pigmentation in smaller-sized Mission olives that were difficult to color. There was no significant change in monoglyceride content of olives after soaking, lye curing, aeration, washing and canning. Taste panel ranking of olives canned after various brine storage periods appeared to confirm the storage time of 12-15 weeks as critical for off-flavor development.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Flavor

- Bomben, J. L., Guadagni, D. G., and Harris, J. G. 1968. Stability of single strength orange juice made with aroma solution of cutback juice. Food Tech. 22:116-118.
- Dreyer, D. L. 1967. Citrus bitter principles. VII. Rutaevin. J. Org. Chem. 32:3442.
- Dreyer, D. L. and Bertelli, D. J. 1967. The structure of zapotin. Tetrahedron 23:4607.
- Dreyer, D. L. 1967. Chemotaxonomy of the Rutaceae. II. Extractives of Severinia buxifolia. Tetrahedron 23:4613.
- Dreyer, D. L. 1968. Citrus bitter principles. VIII. Application of ORD and CD to stereochemical problems. Tetrahedron 24:3273-83.
- Flath, R. A., Henderson, N., Lundin, R. E., and Teranishi, R. 1967. Microcell for nuclear magnetic resonance analyses. Appl. Spect. 21:183.
- Gaffield, William and Waiss, Anthony C., Jr. 1968. Optical rotatory dispersion and absolute configuration of flavanones, 3-hydroxy-flavanones, and their glycosides. Chem. Commun. 1:29-31.
- Gentili, B. and Horowitz, R. M. 1968. Flavonoids of citrus. IX. Some new C-glycosylflavones and a nuclear magnetic resonance method for differentiating 6- and 8-C-glycosyl isomers. J. Org. Chem. 33:1571-77.
- Johnston, K. M., Stern, D. J., and Waiss, A. C., Jr. 1968. Separation of flavonoid compounds on Sephadex LH-20. J. Chromatog. 33:539-41.
- Jurd, L. and Lundin, R. 1968. Anthocyanidins and related compounds. XII. Tetramethylleucocyanidin-phloroglucinol and resorcinol condensation products. Tetrahedron 24:2653-61.
- Jurd, L. 1968. Anthocyanidins and related compounds. XIII. Hydrogen peroxide oxidation of flavylum salts. Tetrahedron 24:4449-57.

- Jurd, L. and Waiss, A. C., Jr. 1968. Anthocyanidins and related compounds. XIV. Reductive dimerization of flavylum salts by metals. *Tetrahedron* 24:2801-8.
- Kutney, J. P., Inaba, Tadanobu, and Dreyer, D. L. 1968. The structure of thamnosin-A novel dimeric coumarin system. *J. Amer. Chem. Soc.* 90:813.
- Lundin, R. E., Elsken, R. H., Flath, R. A., and Teranishi, R. 1967. Methods and applications in the examination of small samples by high-resolution NMR. *Applied Spectroscopy Reviews* 1:131.
- Maier, V. P. and Metzler, D. M. 1967. Grapefruit phenolics. II. Principal aglycones of endocarp and peel and their possible biosynthetic relationship. *Phytochem.* 6:1127-35.
- Mon, T. R., Forrey, R. R., and Teranishi, R. 1967. Effects of addition of adsorption-reducing material with open tubular and packed column gas chromatography. *J. Gas Chromatog.* 5:497.
- Schultz, T. H., Black, D. R., Bomben, J. L., Mon, T. R., and Teranishi, R. 1968. Volatiles from oranges. VI. Constituents of the essence identified by mass spectra. *J. Food Sci.* 32:698.
- Teranishi, R., Lundin, R. E., McFadden, W. H., and Scherer, J. R. 1967. Ancillary Systems, in The Practice of Gas Chromatography, L. S. Ettre and A. Zlatkis, Editors, Interscience, New York-London, pp. 407-459.
- Waiss, A. C., Jr. and Jurd, L. 1968. Synthesis of flav-2-enes and flav-3-enes. *Chem. and Indus.* (June), pp. 743-44.

Color, Texture, and Other Quality Factors

- Coggins, C. W., Jr., Lewis, L. N., and Knapp, J. C. F. 1967. Progress Report: Chemical and histological studies of tough and tender Deglet Noor dates. 44th Date Growers Inst. Annual Report.
- Vandercook, C. E. and Guerrero, H. C. 1968. The effects of chemical preservatives and storage on the constituents used to characterize lemon juice. *J. Assoc. Off. Anal. Chem.* 51:6-10.
- Wilson, K. W. and Crutchfield, C. A. 1968. Spectrophotometric determination of limonin in orange juice. *J. Agr. Food Chem.* 16:118-24.
- Yokoyama, Henry and White, M. J. 1968. The occurrence of ergosterol in citrus. *Phytochem.* 7:493-494.
- Yokoyama, Henry and White, M. J. 1968. Causes of lemon bronzing. *California Citrograph* 53:283.

Yokoyama, Henry and White, Michael J. 1968. Citrus carotenoids. VIII. The isolation of semi-beta-carotenone and beta-carotenone from citrus relatives. Phytochemistry 7:1031-34.

Technology--Process and Product Development

Brekke, J. E. and Allen, L. 1967. Dehydrated bananas. Food Tech. 21:101.

Brekke, J. E. 1968. Banana puree. Proceedings of Banana Symposium, Honolulu, Hawaii, Feb. 24.

Horowitz, R. M. and Gentili, B. 1968. Dihydrochalcone sweeteners. Part I. Preparation and properties; and Booth, A. N. and Robbins, D. J. Part II. Dihydrochalcone subacute toxicity study in rats. USDA CA-74-18.

Horowitz, R. M. and Gentili, B. 1968. Conversion of naringin to neohesperidin dihydrochalcone. U.S. Patent No. 3,375,242.

DECIDUOUS FRUIT AND TREE NUT UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968			
	: Research Problem Area :			
	: 403	: 601	: 702	: Total
California (Albany)	:	:	:	:
Chemical Composition and Physical Properties	:	:	:	:
Color, Texture and Other Quality Factors	: 3.0	: -	: -	: 3.0
Microbiology and Toxicology	: 8.9	: -	: -	: 8.9
Technology--Process and Product Development	: -	: -	: 1.6	: 1.6
California (Pasadena)	:	:	:	:
Chemical Composition and Physical Properties	:	:	:	:
Washington (Puyallup)	:	:	:	:
Technology--Process and Product Development	: 11.1	: 7.6	: -	: 18.7
	:	:	:	:
	: 2.0	: -	: -	: 2.0
	:	:	:	:
	: 0.6	: -	: -	: 0.6
Total	: 25.6	: 7.6	: 1.6	: 34.8

Intramural program is supplemented by extramural support representing
 (a) 0.6 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
 in 3 countries representing 58,640 U.S. dollars equivalent per year.

^{1/} RPA 403 - Color, Texture and Other Quality Factors 0.6 SMY.

Problems and Objectives

Fruits and nuts are valued for their unique flavor, color, and mineral and vitamin content. At harvest time, markets are glutted and growers often do not get an adequate return. Processing makes these commodities available all year and opens new markets for producers, but the unique qualities of these crops are not easily preserved by processing. New and improved products for domestic and foreign markets are needed. The control of microbial contaminants in products and the reduction of water pollution by reducing processing wastes are also critical problems for the processing industry.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing dried fruit and tree nut products acceptable to foreign markets.
2. Controlling microbial contaminants of fruit products.
3. Evaluating processing characteristics of Pacific Northwest berries and fruits.
4. Improving stability and flavor of non-frozen fruit juice concentrates and purees.
5. Improving piece-form and powdered products by dehydration of fruits.
6. Improving fermented fruit products.
7. Improving frozen fruit products.
8. Developing novel methods for controlling plant enzymes in processing and maturation of fruits.
9. Reducing processing wastes from peeling of fruits to minimize pollution.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties

1. Controlling Plant Enzymes. Insoluble but active papain was prepared by the reaction of the enzyme with glutaraldehyde. Insolubilized-active enzymes have many analytical applications and may have industrial applications. The metabolic pathways of the cis and trans isomers of hydroxyproline into protein in plant tissue were found to be different. The findings have

been correlated with auxin-induced growth. Several peroxidase isoenzymes were found to be secreted by plant suspension culture cells. Each isoenzyme probably plays its own particular role in plant metabolism. For this reason the peroxidase isoenzymes of tomato are being isolated and characterized.

Although the functions of steroid hormones in plants are still a mystery, it is becoming increasingly evident that they are synthesized and metabolized in the same way as in animals. Ecdysterone, a molting hormone for insects and crustaceans, is synthesized in radioactive form when radioactive cholesterol is administered to a tree, Podocarpus elata. In foxglove (Digitalis lanata), cholesterol is converted to the progestational hormone, progesterone, by way of pregnenolone. The metabolism of these substances in the plant has been studied. Progesterone was found to be a key intermediate in the synthesis of heart poisons. One of the radioactive products isolated from a primitive tomato plant, Lycopersicon pimpinellifolium, was found to be a sapogenin closely related to tomatidine and another one a certain pregnane derivative. The latter is a steroid which is well known as an industrial intermediate in the synthesis of progesterone from steroidal sapogenins and alkaloids.

B. Flavor

1. Enzymes in Apple Flavor Formation. Supported by P.L. 480 funds, The Federal Research Station for Agriculture, Viticulture and Horticulture, Switzerland, is conducting research to determine the role of enzymes in the formation of apple aroma. Volatile components of apples of the Golden Delicious and Bohnapfel varieties were isolated as oils and separated. One of the quantitatively prevalent fractions was identified as n-hexylacetate.

C. Color, Texture, and Other Quality Factors

1. Anthocyanin and Carotenoid Pigments. The decoloration of flavylum salts under reducing conditions has been studied by using reducing agents that act as hydride ion donors and those (metals) that act by one-electron donation. Colorless dimers are formed by both classes of reducing agents. The structures of these dimers have been elucidated. Experimental work on the possible biogenetic origin of flavonoid pigments has been initiated. Spectral methods for elucidating anthocyanidin structures have been refined and applied to the solution of the structure of aurantinidin. Studies of the formation of leucocyanidin-polyphenol colorless condensation products were completed.

2. Fruit Leucoanthocyanins. P.L. 480 funds are supporting research at the University of Delhi in India where a study of the chemical behavior of leucoanthocyanins in fruits is underway. A number of varieties of pears and apples were studied at an unripe stage. A proanthocyanidin, appearing to be a glucoside of leucocyanidin was isolated from the custard apple. Only fructose was found in the leucoanthocyanidins extracted by cold and hot methanol from apricot kernels. The shell of apricot seeds contains galactose

and a small amount of arabinose but no leucoanthocyanidins. Small quantities of leucoanthocyanidin were found in extracts of peel and pulp of unripe apricot. Flavan-4-ol was more resistant to mild oxidizing conditions than flavan-3-ol. Prolonged treatment of epicatechin tetramethyl ether with dimethyl sulfoxide (DMSO) was required to oxidize it to the keto form. Oxidation of flavan-3,4-diol with DMSO gave a pseudo base as the major product and traces of quercetin tetramethyl ether.

3. Tannin Degradation in Fruits. The Central Leather Research Institute in India, supported by P.L. 480 funds, is seeking biological methods for the degradation of tannins, in order to reduce astringency in fruits. Molds predominantly grow in a medium containing catechin as the sole carbon source. A. flavus previously adapted to dicatechin had the maximum efficiency to utilize catechin and produce extra-cellular enzymes. Factors influencing growth and utilization of catechin by A. flavus were standardized. Concentration of salts in growth medium influences the synthesis and excretion of enzymes that catalyze degradation of catechin to protocatechuic acid and phloroglucinolcarboxylic acid. Optimum composition of inorganic salts, organic and inorganic nitrogen sources, and other conditions of the biosynthesis were investigated. Besides being useful for nutritional requirements of A. flavus sulfate was helpful in releasing enzymes from the mycelium. Ammonium chloride favored the synthesis of enzymes but yield in the filtrate was poor.

4. Polysaccharides in Plant Cell Walls. Supported by P.L. 480 funds, the National Taiwan University in China studied the synthesis of hemicellulose polysaccharides using bamboo shoots. Glycosyl transfer from guanosine diphosphoglucose (GDPG) into a water-insoluble dilute alkali-soluble material was specifically stimulated by the addition of uridine diphosphoxylose (UDPX) while the synthesis of callose from uridine diphosphoglucose was competitively inhibited by the same xylosyl nucleotide. The stimulation by UDPX of glucosyl transfer from GDPG was supposed to be due to the copolymerization of glucose and xylose in the formation of a glucoxytan. UDPX was found to contribute the xylosyl group for the formation of a water soluble pentosan. The polymer formed may be an arabinan. The microfibrils of cell walls of bamboo shoot tissues are spindle shaped and composed of very fine short rod subunits. These structural features of the microfibrils are considered to contribute the very high rate of cell wall expansion as well as the excellent texture of this plant as an edible vegetable.

5. Clarification of Apple Juice. The Colorado State University in Fort Collins is conducting contract research to eliminate cloud and sediment from apple juice. Analyses of sediment and evaluation of commercially packed apple juice after 10 months' storage at 38°, 72° and 100° F. were completed. Samples involved four treatments: (1) regular process (gelatin clarification), (2) regular process (Polyclar clarification), (3) ascorbic acid-sodium chloride treatment of milled pulp (Polyclar clarification) and (4) fortification of juice with ascorbic acid. Ascorbic acid fortification is beneficial except for samples stored at 100° F. Those samples are darker than the non-ascorbic acid samples. Gelatin used in clarification can

react to form sediment later. Chlorogenic acid appears to be of no significance in sediment formation. The principal leucoanthocyanidin from apples has been isolated; preliminary analyses indicate this is probably a dimeric flavanoid.

6. Enzymic Browning of Deciduous Fruit. Supported by P.L. 480 funds, The Hebrew University in Israel studied the nature, activity and distribution of phenolases in deciduous fruits in order to minimize enzymic browning of products.

Browning enzymes were found primarily in the particulate fractions (chloroplasts and mitochondria) in apples, while in peaches and apricots a considerable portion of the enzyme was also present in the soluble fraction. The soluble peach enzyme is entirely distinct from the particulate enzyme of apples and apricots. Several new inhibitors of catechol oxidase were found, namely, 2,3-naphthalenediol, polyvinyl pyrrolidone and its monomer 2-N-vinyl-pyrrolidone. These agents are highly effective in preventing browning of apple slices and may have practical use in that regard. The inhibitors are ineffective against the soluble peach enzyme. Derivatives of the pyrrolidone and closely related compounds hold promise of being effective inhibitors. Catechol oxidase was found to be a family of enzymes with a variable spectrum of activity toward various substrates. This has important basic implications in the future study of the browning enzymes.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Grape Juice Products. Research to devise processes for making new unfermented products from grapes and improved processes for making existing grape products has been initiated.

2. Fermented Grape Products. Progress has been made in defining the factors that determine production rates and product concentrations in reverse-osmosis concentration of agricultural products and byproducts. Experimental results indicate that production rates are limited by concentration polarization. The upper limit of concentration for fruit juices is dictated by the osmotic pressure of the concentrate.

Ion exchange of potassium for calcium in wines was shown to bring about cold stability without changing the cation/anion ratio and without introducing foreign ions to the system.

Sixty components of Concord grape essence were identified by gas chromatography-mass spectrometry methods. Of particular interest were a series of crotonate esters and a possible ethyl thio hexanoate. Comparison of Grenache juice and the corresponding wine shows more esters and some possible acetals in the wine.

Botrytis cinerea culture, extraction, and biochemistry were studied. Activity is dependent on growing temperature. Similarity of endo and exocellular enzymes was indicated.

3. Improved Piece Form and Powdered Fruit Products. Golden Delicious apple segments were osmotically dehydrated in a pilot-plant-scale apparatus in which 70% sugar syrup was pumped continuously over the fruit at 50° C. The apples, after drying to a weight reduction of 50%, were blanched in steam and frozen. Rates of rehydration of the dehydrofrozen apples were measured under various conditions and a system suitable for producing satisfactory pies was worked out. This involved a preliminary soak in water, followed by baking to complete the rehydration. Moisture determinations on a sample of low-moisture apple powder by the vacuum oven method and the Karl Fischer method showed the Fischer method to be much more reliable.

Malecki Laboratories, Inc., Chicago, Illinois, is conducting contract research to develop a continuous fluidized-bed freeze-dryer for making fruit juice powders. Good progress has been made during the initial operation of the fluidized-bed freeze-dryer. Orange juice and apple juice were spray frozen separately by aspirating them onto a spinning disk, while the entire apparatus inside of a chamber was swept by very cold gas and the inside of the chamber walls were bathed in liquid nitrogen. The frozen juice particles, all finer than 30 mesh, were collected and sized by wet screening, using liquid nitrogen. The frozen droplets were then freeze-dried in a fluidized bed. It was found that fluidizing gas temperatures above -25° C. resulted in caking of the particles. At this temperature, of course, freeze-drying is very slow. The use of mechanical stirring or adding anti-caking bodies, either glass beads or very fine anti-caking particles, resulted in a modest improvement. By these means, especially the use of glass beads, bed temperatures could be raised to -10° C.

4. New Soft Fruit and Berry Varieties for Processing. Results of tests that simulated mechanical harvesting conditions indicate that Northwest, Molalla, and Columbia strawberry varieties have the best tolerance for mechanical harvesting. Fresno was the best California strawberry tested for mechanical harvesting tolerance. Of 841 strawberry hybrids tested in 1967, WSU hybrids 1232, 1140 and 1142 had the best quality after freezing.

Mechanically harvested grapes cannot be washed in plant as the berries are often split in harvest. Dirt levels on grapes were measured and found to depend upon vineyard conditions, cover crops and irrigation systems. Grapes from light soils near dusty roads had highest dirt content. Airblast spray washing of grapes before harvesting was an effective way of reducing dirt content of grapes.

Canned cherry samples that had up to 75% bruised fruit held 24 hours before processing were of acceptable quality. Fifty-seven commercially pressed lots of apple juice clarified, filtered, pasteurized, and stored for 3 months showed no haze development.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture, and Other Quality Factors (no current research)
- D. Microbiology and Toxicology (research included in section E)
- E. Technology--Process and Product Development
 - 1. High- and Low-Moisture Products from Dried Fruits. A drum dryer system has been tested on pineapples, blueberries, bananas, apricots, pears, prunes, dates, boysenberries and lemon pulp sacs.

Storage stability tests on heat-treated raisin paste show that an alteration of flavor develops if the heating is conducted prior to grinding. Heating following grinding caused no major alteration of raisin flavor.

The SO₂ levels of dried apricots having 2117 and 1746 ppm SO₂ decreased nearly equally to about 550 ppm after the apricots were boiled for 30 minutes.

Dried fruit products were obtained from processing plants and analyzed for total aerobic bacteria, yeast, mold, coliforms and Salmonella. Results obtained to date indicate that total aerobic bacterial counts and yeast and mold counts are below those of other food items. No coliforms or Salmonella have been detected to date. There is a marked difference in general microbial contents of different dried fruits. Dates were found to have higher counts of organisms.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-ORGANISMS AND NATURALLY OCCURRING TOXINS

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture, and Other Quality Factors (no current research)
- D. Microbiology and Toxicology
 - 1. Radiation Sterilization of Mold Contaminants. Supported by P.L. 480 funds, the Institute of Biology and Agriculture in Austria is conducting research to discover physical and chemical methods of increasing irradiation sensitivity of yeasts and molds to reduce heat requirement for fruit juice pasteurization.

Fewer fruit juice samples showed spoilage after combined treatments with irradiation and heat (50° C.) than after irradiation treatment alone. Byssoschlamys fulva shows only slight production of methyl pectinesterase. Electron microscopic investigations show that the relative radiosensitivity of germinating ascospores is correlated with fragile cell wall structure in this stage of development.

E. Technology--Process and Product Development (no current research)

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

- Bennett, R. D., Sauer, H. H., and Heftmann, E. 1968. Progesterone metabolism in Digitalis lanata. Phytochem. 7:41-50.
- Bennett, R. D., Lieber, E. R., and Heftmann, E. 1967. Time course of steroid biosynthesis and metabolism in Haplopappus heterophyllus. Plant Physiol. 42:973-976.
- Bennett, R. D., Lieber, E. R., and Heftmann, E. 1967. Biosynthesis of neotigogenin and $\Delta^{16-5\alpha}$ -Pregnen-3 β -ol-20-one from cholesterol in Lycopersicon pimpinellifolium. Phytochem. 6:837-840.
- Cleland, R. and Olson, A. C. 1968. Direct incorporation of hydroxyproline into Avena coleoptile proteins. Biochemistry 7:1745.
- De Jong, D. W., Jansen, E. F., and Olson, A. C. 1967. Oxidoreductive and hydrolytic enzyme patterns in plant suspension culture cells: Locale and time relationship. Exptl. Cell Res. 47:139.
- De Jong, D. W. 1967. An investigation of the role of plant peroxidases in cell wall development by the histochemical method. J. Histochem. and Cytochem. 15:335.
- De Jong, D. W., Olson, A. C., Hawker, K. M., and Jansen, E. F. 1968. Effect of cultivation temperature on peroxidase isoenzymes of plant cells grown in suspension. Plant Physiol. 43:841-4.
- Heftmann, E. 1967. Steroid hormones in plants. Am. Perfumer Cosmetics 82:47-49.
- Heftmann, E., Sauer, H. H., and Bennett, R.D. 1968. Biosynthesis of a molting hormone, ecdysterone, from cholesterol by a plant. Naturwissenschaften 55:37-38.
- Heftmann, E. 1967. Biochemistry of steroidal saponins and glycoalkaloids. Lloydia 30:209-230.

Heftmann, E. and Wotiz, H. H. 1967. Chromatography of steroids, in Heftmann, E. (ed.), "Chromatography," Reinhold Publ. Corp., New York, pp. 539-572.

Sauer, H. H., Bennett, R. D., and Heftmann, E. 1967. Pregnenolone metabolism in Digitalis lanata. Phytochem. 6:1521-1526.

Sauer, H. H., Bennett, R. D., and Heftmann, E. 1967. Conversion of pregnenolone to digifoligenin by Digitalis lanata. Naturwissenschaften 54:226.

Color, Texture, and Other Quality Factors

Asen, S. and Jurd, L. 1967. The constitution of a crystalline blue cornflower pigment. Phytochemistry 6:577.

Harel, E., Mayer, A. M., Markus, Z., and Avigad, G. 1967. Inhibition of apple catechol oxidase by a galactose oxidase inhibitor from Dactylium Dendroides. Israel Journal of Botany 16:38-41. 1/

Harel, E. and Mayer, A. M. 1968. Interconversion of sub-units of catechol oxidase from apple chloroplasts. Phytochemistry 7:199-204. 1/

Jurd, L. 1967. A facile new flavan synthesis. Chem. and Ind. 2175.

Jurd, L. 1967. Anthocyanidins and related compounds. XI. Catechin-flavylium salt condensation reactions. Tetrahedron 23:1057.

Jurd, L. and Lundin, R. 1968. Anthocyanidins and related compounds. XII. Tetramethylleucocyanidin-phloroglucinol and resorcinol condensation products. Tetrahedron 24:2653.

Jurd, L. 1968. Anthocyanidins and related compounds. XIII. Hydrogen peroxide oxidation of flavylium salts. Tetrahedron 24:4449-57.

Jurd, L. and Waiss, A. C., Jr. 1968. Anthocyanidins and related compounds. XIV. Reductive dimerization of flavylium salts by metals. Tetrahedron 24:2801.

Sharon, Miriam and Mayer, A. M. 1967. The effect of sodium chloride on catechol oxidase from apples. Israel J. Chem. 5:275-80. 1/

Technology--Process and Product Development

Boyle, F. P. 1968. Current enological studies at WRRRL. Wine Institute Technical Advisory Committee Bulletin (Jan.).

1/ Research supported by P.L. 480 funds.

- Boyle, F. P. and Wolford, E. R. 1968. The preparation for freezing and freezing of fruits. Chapter 3, Vol. III of "Freezing Preservation of Foods," Avi Publishing Company.
- De Jong, D. 1968. Some aspects of Botrytis cinerea enzymology. Wine Institute Technical Advisory Committee Bulletin (Jan.).
- De Jong, Donald W., King, A. Douglas, and Popper, Karel. 1968. Oxidative activity of Botrytis cinerea extracts in alcohol. Proc. Fed. Am. Soc. Exptl. Biol. 27:808.
- Gaffield, William and Waiss, A. C., Jr. 1968. Optical rotatory dispersion and absolute configuration of flavones. Chem. Communications (London, England) 29.
- Ingalsbe, D. W., Clore, W. J., and Cone, W. E. 1967. Measurement and removal of dirt on Concord grapes grown in central Washington in 1967. Wash. Agr. Exp. Station Circular.
- Johnston, K. M., Stern, D. J., and Waiss, A. C., Jr. 1968. Separation of flavanoid compounds by Sephadex LH 20. J. Chromatog. 539.
- Popper, K., Merson, R. L., and Camirand, W. M. 1968. Osmosis-reverse osmosis couple. Science 159:1368.
- Popper, K., Merson, R. L., Camirand, W. M., and Boyle, F. P. 1967. Possible use of osmosis-reverse osmosis for concentration. Wine Institute Bulletin (Dec.).
- Popper, K. and Boyle, F. P. 1967. Some unorthodox approaches to ion exchange treatments of wine. Wine Institute Technical Advisory Committee Bulletin (Dec.).
- Popper, K., King, A. D., Jr., and Boyle, F. P. 1967. Wines and molds: noble and ignoble. Hornblower 21:8-9.
- Popper, K., King, A. D., Jr., Boyle, F. P., Camirand, W. M., De Jong, D. W., and Stanley, W. L. 1967. Of must and mold. Wines and Vines 48:17-18.
- Popper, K., Camirand, W. M., Watters, G. G., Bouthilet, R. J., and Boyle, F. P. 1967. Recycles process brines--prevents pollution. Food Eng. 39:78-80.
- Popper, K., Nury, F. S., and Stanley, W. L. 1967. Acid fume peeling of fruit. U.S. Patent No. 3,336,960.
- Stern, D. J., Lee, A., McFadden, W. H., and Stevens, K. L. 1967. Volatiles from grapes. Identification of volatiles from Concord essence. J. Ag. & Food Chem. 15:1100.

- Stevens, K. L., Bomben, J. L., and McFadden, W. H. 1967. Volatiles from grapes. Vitis vinifera (Linn.) cultivar Grenache. J. Ag. and Food Chem. 15:378.
- Waiss, A. C., Jr., Lundin, R. E., Lee, A., and Corse, J. 1967. Photo-chemistry of quercetin pentamethyl ether. J. Am. Chem. Soc. 89:6213.
- Wolford, E. 1967. Freezing Hood and Northwest strawberries. Proceedings of Western Washington Horticultural Association.
- Wolford, E. R., Ingalsbe, D. W., and Boyle, F. P. 1967. Freezing of peaches and sweet cherries in liquid nitrogen and in dichlorodifluoromethane and behaviour upon thawing of strawberries and raspberries. Proceedings of XII International Congress of Refrigeration, International Institute of Refrigeration.
- Wolford, E. R. 1968. Processing characteristics of the newer Washington State University strawberry hybrids. Proceedings of Western Washington Horticultural Association.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

Technology--Process and Product Development

- Bolin, Harold R., Boyle, Frank P., and Nury, Fred S. 1967. Time temperature storage study of dried apples and heat-treated ground raisins. Seventh Annual Research Conference of the Dried Fruit Industry Research Advisory Committee, Davis, Calif., pp. 9-25.
- Bolin, Harold R., Porter, James L., and Boyle, Frank P. 1967. A review of current research on dried fruits and tree nuts at Western Regional Research Laboratory. Seventh Annual Research Conference of the Dried Fruit Industry Research Advisory Committee, Davis, Calif., pp. 32-44.
- Bolin, Harold R. and Boyle, Frank P. 1967. Use of potassium sorbate, diethylpyrocarbonate and heat for the preservation of prunes at high moisture levels. J. Sci. of Food and Agr. 18:289-291.
- Bolin, H. R. and Porter, James L. 1967. Stabilizes color of fresh prune juice. Food Processing and Marketing 26:50.
- Bolin, Harold R., Guadagni, D. G., Porter, James L., and Boyle, Frank P. 1968. Storage stability of ground heat-treated raisins. Food Techn. 22:120-2.
- Lazar, M. 1968. Modified drum drier shows versatility. Food Eng. 40:95-7.
- Nury, F. S. and Salunkhe, D. K. 1968. Effects of microwave dehydration on components of apples. USDA ARS 74-45, 19 pp.
- Stanley, William L. 1968. Utilization of apples by new processing techniques. Wash. State Hort. Assoc. Proc., 63rd Annual Meeting, Wenatchee, Wash. (Dec.), pp. 129-30.

POTATO UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968		
	Research Problem Area :		
	403	901	Total
California (Albany)			
Technology--Process and Product Development	3.9	1.8	5.7
Total	3.9	1.8	5.7

Intramural program is supplemented by extramural support representing
(a) 0.6 SMY's per year at State Agricultural Experiment Stations^{1/},
(b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
in 2 countries representing 27,736 U.S. dollars equivalent per year.

1/ RPA 403 - Chemical Composition and Physical Properties 0.6 SMY.

Problems and Objectives

An historic decline in per capita potato consumption has been reversed by growth of markets for processed products. Consumption has been stabilized at about 110 lbs. since the early 1950's through market growth for processed potatoes. To hold these markets, new and improved products and processes of lower cost must continue to flow from research.

Establishment of large manufacturing plants for potato products has concentrated potato waste which now must be treated to prevent pollution of streams, rivers and lakes. Processes of manufacture must be changed to reduce pollution from potato processing.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving color, flavor, texture, and stability of potato products at no net increase in cost.
2. Eliminating the organic matter and lye that contribute to processing plant waste effluents as a result of peeling potatoes for commercial processing.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties

The following investigations provide basic information currently needed to develop potato products with improved color and flavor stability.

1. Lipid Synthesis. In contrast to a previously reported dramatic increase of biosynthetic enzymes in aged potato slices, beta-oxidation of fatty acids, a key step in their degradation, is as fully functional in fresh as in aged potato slices. The key enzyme reaction activated during fatty acid biosynthesis in aging potato slices involves conversion of oleyl CoA to linoleyl CoA. Potato slices convert propionic acid to beta-hydroxy propionic acid or its lactone, rather than succinate, as concluded by other workers.

Studies to determine why some seeds have low lipid contents were initiated. Fatty acid synthetase was found in various subcellular fractions of very young seedlings. This research is conducted under a grant to the University of California at Davis.

2. Autoxidation of Fats. In model systems of unsaturated fatty acids or their esters, a reduction of oxygen tension does not sharply lower the rate of oxidation. Histidine, tryptophane, glycine and alanine had an antioxidant effect and reduced the rate of oxygen absorption. Phenolic antioxidants on the other hand prolonged the induction period but did not

affect the ultimate rate of oxidation once the induction period was over. Copper and manganese ions and, to a lesser extent cobalt and iron, can act as antioxidants at low oxygen pressures. Metal ions are well known to be pro-oxidants for fats exposed to air, but the metallic antioxidant effect occurs when the oxygen concentration of the atmosphere is reduced to a few percent or less. This antioxidant effect was enhanced as the pH of the system was reduced from 7 to 5. At low oxygen pressure reaction products of fat oxidation contained relatively more carbonyl compounds. When model systems were freeze dried a much lower oxygen pressure was required to decrease the rate of oxidation by a given amount. Low oxygen pressure was much more effective in reducing oxidation rate in freeze-dried carrots than in model systems. This research, supported by a P.L. 480 grant to The Swedish Institute for Food Preservation Research, Sweden, has been concluded.

3. Role of Metals in Vegetable Enzyme Action. Enzymes representing different types of metal involvement are investigated: (1) a metal-activated enzyme, 3-phosphoglycerate kinase; (2) two non-oxidase metalloenzymes, carbonic anhydrase and alkaline phosphatase; and (3) two metal-containing oxidases, laccase and tyrosinase. With the first type the major function of the metal ion is to combine with one of the substrates.

Carbonic anhydrase was studied in three aspects: the amino acid side chains in the active site, the sequence of amino acid residues, and certain physical properties (reaction velocities, metal binding, structure in solution). Two histidine residues in human carbonic anhydrase B are in positions close to the active site. The amino acid sequence in the COOH-terminal region was determined for three forms of the enzyme. Similarities are found not for isoenzymes from the same species but rather from kinetically similar forms from different species.

Alkaline phosphatase binds zinc ion at two independent and identical sites. The metal influences the process of association of these subunits, but is not essential for holding them together.

Two cupric ions in laccase are not bound in an identical manner and only one form is rapidly reduced by substrate.

This research is being conducted under a P.L. 480 grant to the University of Gothenburg, Sweden.

B. Flavor (no current research)

C. Color, Texture and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Potato Product Quality. Development of improved processes to control discoloration in processed potatoes is the subject of investigations on

enzymic reactions of potato tissues and effects of bruising on enzyme systems relative to incidence of internal blackspot. Two histochemical methods to identify tyrosine in potato tissue were developed. One is based upon metal chelation by nitrosotyrosine which is formed by the action of nitrous acid. The other method involves a coupling of the products of a diazotization reaction with S-acid. In potatoes tyrosine is of general distribution, slightly concentrated toward the stem end and more concentrated in the inner storage parenchyma than in the cortex. Chlorogenic acid concentrations were highest in the cortex.

Consistently uniform relationships between phenolase and blackspot susceptibility were found after improvement of the analytical methods used. No relationship was found between pre-injury phenol concentration and blackspot susceptibility. Bruising caused a significant increase in total polyphenols and chlorogenic acid. Russet Burbank and Red Pontiac potatoes were bruise-tested for blackspot susceptibility, which was compared with enzyme activity and substrate content. Russet Burbank tissue was relatively resistant to blackspot in November but became more susceptible with prolonged storage.

RPA 901 - ALLEVIATE SOIL, WATER, AND AIR POLLUTION

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture and Other Quality Factors (no current research)
- D. Microbiology and Toxicology (no current research)
- E. Technology--Process and Product Development

1. Reducing Wastes from Peeling Potatoes. A new potato peeling method has been developed. The method avoids the use of water sprays in removing 90% to 95% of the peel and adhering tissue. Potatoes are sprayed or dipped in a 20% solution of caustic soda for 50 to 100 seconds, drained, and held at room temperature for 5 minutes. Then the potatoes are tumbled in a rotating drum and exposed to radiation from a gas-fired source for 2 to 5 minutes. About half of the peel solids are removed in the drum. The potatoes then go through rotating rolls covered with many flexible rubber fingers. The other half of the peel solids is removed in this step. The remaining 5% of the softened potato tissue is removed in a barrel or brush washer. Adjustment of variables has provided satisfactory peeling of all potatoes likely to be processed. Commercial processors have shown a great interest in this new method since it offers a possibility of reducing costs of waste disposal now required to meet federal and state regulations regarding water quality in streams, rivers, and lakes.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Chemical Composition and Physical Properties

Falk, K. E., Freeman, H. C., Jansson, T., Malmstrom, B. G., and Vanngard, T. 1967. Magnetic resonance studies of copper(II)--triglycylglycine complexes. Journal of the American Chemical Society 89:6071. ^{1/}

Nilsson, A. and Lindskog, S. 1967. Hydrogen ion equilibria and the chemical modification of lysine and tyrosine residues in bovine carbonic anhydrase B. European J. Biochem. 2:309-317. ^{1/}

Thurslund, A. and Lindskog, S. 1967. Studies of the esterase activity and the anion inhibition of bovine zinc and cobalt carbonic anhydrases. European J. Biochem. 3:117-123. ^{1/}

Technology--Process and Product Development

Boyle, Frank P. 1967. Dehydrated mashed potatoes: potato granules. Potato Handbook, American Potato Association.

Feinberg, Bernard, Olson, Robert L., and Mullins, W. R. 1967. Prepeeled potatoes. Potato Processing, 2d ed., W. F. Talburt and O. Smith, eds., Avi Publ. Co., Westport, Conn., 491-519. Also Potato Handbook 12:70-71.

Reeve, R. M. 1967. A review of cellular structure, starch, and texture qualities of processed potatoes. Economic Botany 21:294-308.

Reeve, R. M., Boyle, F. P., Feinberg, B., and Notter, G. K. 1968. Deterioration of frozen par-fried potatoes upon holding after thawing. I. Objective measurements of color and fat absorption. Food Technol. 22:91-93.

Reeve, R. M., Feinberg, B., Boyle, F. P., and Notter, G. K. 1968. Deterioration of frozen par-fried potatoes upon holding after thawing. II. Composition, histology and objective measurement of texture. Food Technol. 22:94-98.

Schwimmer, Sigmund and Burr, Horace K. 1967. Structure and chemical composition of the potato tuber. In Potato Processing, 2d ed., W. F. Talburt and O. Smith, eds., Avi Publ. Co., Westport, Conn. 12-43. Also Potato Handbook 12:42-5.

Zaehring, M. V., Reeve, R. M., Talley, E. A., Dinkel, D. H., and Hyde, R. B. 1967. Specific gravity and composition of potatoes for various processing and cooking purposes. Potato Handbook 12:5-12.

^{1/} Research supported by P.L. 480 funds.

VEGETABLE UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	: Scientist Man-Years F.Y. 1968			
	: Research Problem Area :			
	: 403	: 601	: 702	: Total
California (Albany)	:	:	:	:
Flavor	:	:	:	:
Color, Texture and Other Quality Factors	: -	: 3.7	: -	: 3.7
Microbiology and Toxicology	: 3.8	: -	: -	: 3.8
Technology--Process and Product Development	: -	: -	: 6.4	: 6.4
California (Pasadena)	:	:	:	:
Technology--Process and Product Development	: 6.4	: 3.0	: -	: 9.4
Washington (Puyallup)	:	:	:	:
Microbiology and Toxicology	: 0.5	: -	: -	: 0.5
Technology--Process and Product Development	: -	: -	: 0.1	: 0.1
	: 0.4	: -	: -	: 0.4
Total	: 11.1	: 6.7	: 6.5	: 24.3

Intramural program is supplemented by extramural support representing
 (a) 0.9 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
 in 2 countries representing 51,865 U.S. dollars equivalent per year,

^{1/} RPA 701 - Technology--Process and Product Development 0.3 SMY,
 RPA 702 - Microbiology and Toxicology 0.6 SMY.

Problems and Objectives

Vegetable crops are perishable and seasonal and thus subject to disadvantageous supply and price fluctuations. New products and processed products of improved quality, stability, convenience, nutritive value, safety and cost are needed to sustain domestic and build foreign markets. Processing operations must be changed to cope with the effects of mechanical harvesting and field handling of raw materials. Increased use of agricultural chemicals may require processing changes to mitigate effects of residues. Wastes from processing operations must be handled at reduced costs to prevent polluting soils and bodies of water.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Improving quality and stability of dehydrated vegetables for export.
2. Insuring removal of harmful agricultural residues in processing.
3. Protecting canned low-acid foods and other vegetable products from spoilage bacteria and from microbial contaminants.
4. Improving and developing new and improved foods by evaluating processing characteristics of new varietal selections; devising processes to create convenient, non-flatulent products from dry beans and peas; controlling the consistency of tomato products; and devising better methods for preserving the textural characteristics of frozen vegetables.
5. Alleviating soil and water pollution from vegetable processing wastes.

Progress - USDA and Cooperative Programs

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor

1. Aroma and Taste Components of Hops. The rate of photolysis of copululone to 4-desoxycophumulone was markedly increased by addition of riboflavin triphosphate as a photosensitizer. Analysis of green and sulfur-dried hops for the presence of methyl thiohexanoate showed that this sulfur compound (a powerful odorant) is a natural component of the hops and is not formed by the sulfur treatment. This investigation of hop components provides basic information currently needed to develop new products for use in brewing.

C. Color, Texture and Other Quality Factors

1. Improved Dry Bean Products. A dry bean fraction exhibiting a 10-fold concentration in flatulence activity was separated by ion exchange into three subfractions for controlled evaluation. Data analysis is in progress.

An alcoholic extract of beans does not inhibit carbonic anhydrase which probably is a major factor in the transport of CO₂ from the intestine. Addition to such bean extracts of appropriate enzymes, such as are likely to be present in intestinal bacteria, results in a progressive formation of a substance(s) which does inhibit carbonic anhydrase. Among substances likely to be produced by bacterial enzymic action on beans is hydrosulfide ion or sulfide ion which is an extremely potent inhibitor of mammalian carbonic anhydrase. Accumulation of CO₂ in the lower intestine associated with bean flatulence may be the result of many factors. One source of CO₂ may be bacterial fermentation of non-absorbable substances, but inhibition of CO₂ transport across the intestinal wall might also be essential to accumulation.

An assay procedure was developed for estimation of a factor in Lima and other dry beans which stimulates gas production and growth of the common intestinal anaerobe, Clostridium perfringens. Starch and simple carbohydrates did not stimulate gas production by this assay method. However, a variety of dry beans reproducibly stimulated prolific gas production. Non-flatulent, bland foods such as barley and rice produced minimal responses.

This investigation provides basic information currently needed in the development of convenient, non-flatulent food products from peas and beans.

Phytate content of Pinto beans increases during early seed development. Dry beans contain about 1% phytate, half the total acid-soluble phosphorus. This research provides basic information currently needed to develop convenient quick-cooking bean products of uniform tenderness.

2. Bean Proteins. Defatted seed meals of Acacia catechu, A. suma, Cassia occidentalis, C. obtusifolia, Mucuna pruriens, Dolichos biflorus, Glycine hispida and Pithecellobium dulce were analyzed for nitrogenous constituents at various pH. Semi-quantitative fractionation based on solubility characteristics and isolation of proteins in appreciably pure form were completed. All seeds examined contained globulin as their major protein component varying from 46 to 83% of the total nitrogen content. Amino acid composition of purified globulins is under investigation.

Albumins isolated from 5 varieties of Phaseolus seeds were analyzed for amino acid composition. All samples contained 14-18 amino acids. Chemical analysis for essential amino acid content revealed them to be of adequate nutritive value. Biological evaluations are underway.

A new amino compound from seeds of Crotalaria juncea was isolated and purified and characterized. A tentative structure was proposed.

This research at the Allahabad University in India is supported by a P.L. 480 grant to provide information necessary for the development of new and improved processes and products to increase utilization of dry beans.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Physical Characteristics of Heat Processed Tomatoes. High consistency tomato juice and paste were successfully prepared on a small pilot-scale controlled pH-break processing line with a capacity up to 1000 lbs. per hour. These products were prepared in the pH range of 1.0 to 3.0 at temperatures of 190 to 200° F. Samples are in storage at 34° and 90° F. for periodic evaluation.

Other high consistency juices were prepared at pH 6.0. These juices have a tendency to gel; however, when they are mixed with juices prepared at the natural fruit pH, pastes of improved consistency are obtained after concentration. The effects of pH and temperature on losses of juice consistency and serum viscosity during processing delays were investigated. Changes at 160° F. were slight compared to damage occurring at 190° to 212° F. Within the pH range of 2.0 to 4.5, rates of viscosity loss were roughly equal for samples held at the same temperature. At pH 6.0 loss rates were several-fold those observed at the lower pH.

2. Texture of Frozen Vegetables. Microwave blanching and steam blanching of corn-on-the-cob were evaluated by sensory panel appraisal of samples stored at 0° F. Steam-blanching samples stored at -20° F. were used as reference samples. Nine-month and twelve-month storage gave similar results--no difference between reference samples and samples stored at 0° F. after the following treatments: 8 min steam, 12 min steam, 4 min microwave, and one combination involving hot water and microwave blanch. After 9 months' storage at 0° F., underblanched (by peroxidase test) microwave-blanching samples were inferior to adequately blanching samples. Eight-min steam-blanching samples were inferior to 12-min samples. The best microwave-blanching (4 min) and steam-blanching (12 min) samples contained some residual peroxidase; peroxidase-free samples (6.1 min microwave) were inferior.

Test panels detected no difference among three samples of blast-frozen asparagus which showed slight freezing damage confined to vascular and sub-epidermal tissues. They were able to distinguish them from other blast-frozen samples without damage, or from package-frozen asparagus with extensive visible damage.

With zucchini squash samples cooked for 1 min, test panels detected differences between slightly, moderately, or severely damaged blast-frozen slices. Moderately and severely damaged samples were not distinguished. With longer cooking times the differences were more apparent and panel

members expressed a significant preference for the firmest samples which were those exhibiting least observable tissue damage.

Asparagus, Snow peas, snap beans, Romano beans, corn, carrot sticks, cauliflower and Brussels sprouts were frozen by immersion in liquid Freon-12 at -22° F. and evaluated. Flat podded vegetables showed splitting along the suture during freezing. Repeated short dips in the freezant lessened the splitting. Immersion for extended periods did not cause more extensive splitting than 30 seconds immersion. Extended contact with liquid nitrogen on the other hand causes shattering of food products. Freon-frozen carrot sticks when thawed retained a crispness in texture that cannot be attained by conventional freezing. Asparagus, Snow peas, snap beans, Romano beans, cauliflower and Brussels sprouts were judged to have better texture than conventionally frozen products.

3. Improved Dry Bean Products. A convenient and economical process that will permit institutional users to process and prepare their own quick-cooking Lima beans was developed. Educational, commercial and military food preparation centers may use available equipment for processing. Dry beans are soaked overnight in a solution of common, food-grade inorganic salts. The soak solution is discarded and the beans are cooked for 10 to 15 minutes. Uncooked beans thus soaked may be frozen and stored for future use.

Large-scale processes for quick-cooking dry beans appear technically feasible for Pintos, California Small White and Great Northern beans and black-eyed peas.

A variety of legume powders stored in air for 12 months or longer developed a distinct off-odor. The off-odor, along with the fatty components, was extracted with ether. Thiobarbituric acid tests indicated relatively little malonaldehyde had accumulated, although this is usually regarded as a good index of fat rancidification. Aldehydes and ketones were not present in detectable concentrations in stored bean, pea, or lentil powders.

Drum-dried bean powder had a higher lipids content than comparable tray-dried beans or ground raw beans. Free fatty acid content of bean powders cooked before being dried was only one-eighth that of ground raw beans, indicating a contribution of the cooking step to flavor stability. Production rates per square foot of drum surface were similar on a small double-drum dryer and a larger double-drum dryer converted for use as a single-drum machine. Product quality was similar for both equipments.

4. New Vegetable Varieties for Processing. Alar (trade name) slows maturation of Brussels sprouts but tops them chemically, thus eliminating a labor cost of \$12-\$15/acre. In addition, it produces a firmer sprout and one that requires less blanching, which should result in better color. This is an example of new cultural practice which can result in improved quality of a frozen vegetable.

The Jade Cross Brussels sprout yields well in the Puget Sound area of Washington State but it would make a better frozen pack if it had more compact heads and a deeper green color. The newer hybrids, as well as the variety Hedda, appear to have characteristics that will attract more processors.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor

1. Chemistry of Vegetable Flavor Compounds. Intramural and P.L. 480 grant research is conducted to obtain basic information currently needed to improve quality and stability of dehydrated vegetables for export.

Among more than 400 persons screened for their sensitivity to odors, 10 were found who were remarkably and specifically insensitive to the odors of short chain fatty acids. Further comparisons of these "specific anosmics" with a group of 97 normal observers provided the first systematic experimental definition of a primary odor, "sweaty," and the corresponding primary odorant, isovaleric acid (3-methyl butanoic acid).

Trans-S-(1-butenyl)-L-cysteine sulfoxide cyclizes in a manner similar to the cis-propenyl analog but differs from the natural trans propenyl compound which is the natural flavor precursor of onions. Two isomers are produced in the non-natural model compounds and the structures of these isomers were elucidated. The bitter material produced enzymically when onions are crushed or the juice expressed from them was separated into four sulfur-containing components as oils. The compounds also contain oxygen. Three crystalline 2,4-dinitrophenyl sulfides were prepared from one of the bitter components by LiAlH_4 reduction and reaction with 1-chloro-2,4-dinitrobenzene. The bitter flavor and most of the typical fresh onion aroma, as well as the odor of cooked onions, arise from enzymic and chemical reactions of trans-S-(1-propenyl)-L-cysteine sulfoxide.

Preliminary experiments with a bitter substance of artichoke indicate that the bitter principle is extremely heat labile or convertible by enzymic action to yield essentially flavorless components.

Related investigations are conducted at the Biochemical Institute, Finland, supported by P.L. 480 funds. Purification and characterization of chemical structure of still unknown compounds of Allium species are in progress, including a detailed study of the biosynthesis of characteristic sulfur compounds. For comparison the biosynthesis of homologous compounds found in marine algae is under investigation. Methodology for sensitive, rapid analysis of such compounds is being improved. A probable pathway for biosynthesis of cycloalliin, a major sulfur compound of wild onion, was elucidated. Enzymic splitting of glucotropaeolin in garden cress seeds is under investigation.

C. Color, Texture and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Dehydrated Vegetable Stability. Dehydration of celery by extraction of water with alcohols greatly improves rehydration characteristics compared to commercial air-dried products. However, a simultaneous extraction of chlorophyll and other aqueous alcohol-soluble constituents occurs. Losses of solutes, including chlorophyll, can be reduced when dehydration is accomplished by suspending diced celery samples in the vapor phase of water-organic liquid azeotropic mixtures. Mixed aliphatics, isopropanol, cyclohexane, benzene, and a 1:3 mixture of isopropanol and cyclohexane were used. Rehydration indices were intermediate to the extremes previously reported for solvent-extraction and air-drying. Liquid phase extraction still occurs in the azeotropic system due to condensation on the sample surface.

Celery slices were soaked in 60% sucrose for 10 min, at room temperature before dehydration at 150° F. and bin-drying at 119° F. The sucrose-treated dried slices remained pliable but contained about 64% added sucrose. When rehydrated these slices had improved shape, size, and texture over controls. However, a series of rehydration treatments indicated that the improved appearance was due to the direct effect of sucrose on piece volume and not due to improved water binding capacity of the celery tissue.

RPA 701 - INSURE FOOD PRODUCTS FREE FROM TOXIC RESIDUES
FROM AGRICULTURAL SOURCES

A. Chemical Composition and Physical Properties (no current research)

B. Flavor (no current research)

C. Color, Texture and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Changes in Pesticide Residues During Processing. Contract research at the National Cannery Association, California, was initiated on chemical changes in pesticide residues during processing of fruits and vegetables to facilitate preserving products that meet pesticide residue standards.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-
ORGANISMS AND NATURALLY OCCURRING TOXINS

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture and Other Quality Factors (no current research)
- D. Microbiology and Toxicology

1. Heat Resistance, Dormancy, and Germination of Spores. Resistance of bacterial spores to dry heat can be changed from a sensitive to a resistant state in the same way as shown previously for resistance to moist heat. Sensitized spores of B. stearothermophilus had about the same survival rate at 105° C. as resistant spores at 125° C. Exposing spores to acid and then washing and drying them produces the sensitive state. Neutralization by metal ions produces the resistant state. A process for sterilizing low-acid foods based on the conversion and retention of the sensitive state of spores in the food has been improved by use of CO₂ in the reneutralized food. The resultant temporary lowering of the pH during the heat process increases the sensitivity of spores to heat.

Several heterocyclic dicarboxylic chelating agents were synthesized for a correlation of geometry, calcium-binding strength, and other parameters with efficacy in a calcium-dipicolinate type germination. X-ray crystallography of several of these synthesized compounds is underway to test a hypothesis for the mode of action of calcium-dipicolinate type germination.

These investigations to provide basic information currently needed to develop improved methods for preserving low-acid foods were supplemented by a recently concluded P.L. 480 grant to the National Institute of Agronomic Research, France. Information was obtained on biosynthesis, purification, and properties of alanine and leucine dehydrogenases from B. subtilis SJ 2. This strain was chosen long ago for its unusual dormancy, and amino acid requirements for germination. The content of enzymes can be varied independently in the vegetative cells but not in the spores (not even in spores of mutant strains). The enzymes were purified extensively and separated physically from each other. They exhibit many similarities except in their substrate specificities. Attempts were made to relate activities of these enzymes to the germination process but details of the latter remain obscure. In electron micrographs a "vesicular stage" of the spore core has been seen. This stage precedes changes in spore refractivity.

2. Sporulation of Food Spoilage Bacteria. Relationship of abnormal morphology (filamentous growth), metabolism of L-arabinose (a pro-sporulation factor), and yield of spores of Clostridium thermosaccharolyticum 3814 is under study. Fluoroacetate at 0.005M represses sporulation but not growth;

less ethanol but more citric acid (or a new compound) are formed than in the absence of the inhibitor.

Vegetative cells have been grown on pyruvate (poor sporulation) and L-arabinose (good sporulation). The cells were disrupted and the hexokinase activities fractionated on DEAE cellulose columns and also by disc electrophoresis. Sporulating cells became long and thick in contrast to bacilli and to some other clostridia which become short and thick during sporulation. This research is being supported by a research grant to the University of Illinois.

3. Control of Microbes in Frozen Vegetables. Twenty-five of 153 line samples from pea and cut bean freezing operations had high bacterial counts (over 50,000 per gram). Most frequent sources of high counts were distributors at freezing tunnel entrance (8 samples) and the intake (4 samples) and discharge (6 samples) of pneumatic conveyors. High counts were found when vegetable particles accumulated on line equipment, especially in locations away from the main part of the processing line. Positive presumptive coliform tests were found in 59 samples. Nine of the line samples had more than 10 colonies per 0.1 gram sample which is the maximum tolerance of some commercial buyers. Aerobacter aerogenes was the dominant coliform isolated Escherichia coli was recovered from 5 samples but its recovery did not appear to be tied with obvious human contamination nor with high plate counts.

Plate counts from frozen cooked squash ranged from 0.8×10^6 to 3.1×10^6 per gram. These high counts were traced to accumulation of squash solids on the machinery in the line, to inefficient cooling of the cooked product, and to inadequate cleaning of the machinery in the line. In order to meet commercial specifications for low bacterial count in frozen vegetable processing lines, attention must be given to proper cleaning of areas where high counts are found. Production of low count frozen cooked squash requires sanitary construction of lines that eliminate pockets, efficient cooling of the hot puree and thorough and frequent cleaning of lines.

4. Control of Microbes in Dehydrated Vegetables. Sliced onions are dehydrated at moderate temperatures without blanching. Dry and wet cleaning of onions before peeling resulted in small to moderate reductions of total bacterial counts. Washing whole peeled onion, onion slices or onion layers with water or solutions of detergents or bactericidal agents did not cause a major reduction in bacterial count, suggesting that bacteria are imbedded within the onion tissue. Heating sliced onions for 2 minutes at 120° F. reduced counts more than any cold washing treatment. Higher temperatures, longer heating times or use of antibacterial additives further reduced total counts but high temperatures caused loss in onion pungency. Total plate counts increased up to 10-fold when sliced onions were held for 4 to 8 hours before dehydration. This investigation is supported by a research contract to the University of Illinois.

E. Technology--Process and Product Development

1. Removal of Radioactive Fallout. Contract research concerned with the removal of external and internal radioactive materials from fruits and vegetables during processing has been concluded at the National Canners Association in California.

Raw potatoes grown in soil contaminated with radiostrontium were prepared in the form of cubes, shreds, and puree, mixed with water and shaken with ion exchange resin. From 4 to 24 percent of the radioactivity was removed from the solid fraction of the potato. Spray rinsing of strawberries removed only about 30% of external contamination with radiostrontium and 12% of internal contamination. However, when strawberries were blended, diluted with an equal volume of water, and centrifuged, and the supernatant was treated with carbonate to precipitate strontium and calcium, 97% of the radioactivity was removed and 43% of the strawberry material was recovered. There was a 27% loss of ascorbic acid. The final product had a salty taste but would be acceptable under emergency conditions.

Decontamination of potatoes internally contaminated with radiostrontium by treatment with ion exchange resins is not very promising. However, the excellent decontamination of strawberry solubles by precipitation of the strontium with carbonate ion is encouraging.

Publications - USDA and Cooperative Program

RPA 403 - NEW AND IMPROVED FRUIT AND VEGETABLE PRODUCTS

Flavor

Buttery, R. G., Black, D. R., Lewis, M. J., and Ling, L. 1967. A study of the fate of volatile hop constituents in beer. J. Food Sci. 32:414.

Fernandez, C. M. 1967. Photochemical conversion of colupulone to 4-desoxycohumulone. Chemical Communications (London), 1212.

Color, Texture and Other Quality Factors

Burr, Horace K. and Kon, Samuel. 1967. Factors influencing the cooking rate of stored dry beans. Report of Eighth Dry Bean Research Conference. ARS-74-41, 50-52.

Murphy, E. L. 1967. The measurement of human flatulence. Report of 8th Dry Bean Research Conference. ARS-74-41, 71-74.

Sanchez, Roland, Tucker, Carl, and Murphy, E. L. 1967. The development of the flatulence principle in the maturing bean. Report of 8th Dry Bean Research Conference. ARS-74-41, 53-56.

Technology--Process and Product Development

- Bakker-Arkema, F., Patterson, R. J., and Bedford, C. L. 1967. Drying characteristics of pea beans on single and double drum dryers. Trans. Am. Soc. Agric. Eng., 10:154-156.
- Neumann, H. J., Dietrich, W. C., and Guadagni, D. G. Dec. 1967 and Jan. 1968. Delay in freezing harvested peas results in detectable off-flavor. Quick Frozen Foods, 101 and 64.
- Rockland, L. B. and Metzler, E. A. 1967. Preparation of frozen quick-cooking legumes. U.S. Patent No. 3,352,687.
- Wagner, J. R. and Miers, J. C. 1968. Methods for preparing high-consistency tomato juice. U.S. Patent No. 3,366,489.
- Wagner, J. R., Miers, J. C., and Burr, H. K. 1968. Preparation of high-consistency tomato juice. U.S. Patent No. 3,366,490.
- Wagner, J. R., Miers, J. C., and Burr, H. K. 1968. Production of high-consistency tomato juice. U.S. Patent No. 3,366,488.

RPA 601 - EXPANSION OF FOREIGN MARKETS FOR U.S. PRODUCTS

Flavor

- Amoore, J. E., Palmieri, G., and Wanke, F. 1967. Molecular shape and odour: Pattern analysis by PAPA. Nature 216:1084-1087.
- Amoore, J. E. 1967. Stereochemical theory of olfaction. In Symposium on Foods--Chemistry and Physiology of Flavors, edited by H. W. Schultz, E. A. Day and L. M. Libbey, Avi Publishing Co., Westport, Conn., 119-147.
- Amoore, J. E. and Venstrom, Delpha. 1967. Correlations between stereochemical assessments and organoleptic analysis of odorous compounds. "Olfaction and Taste II." Proc. of Second Intl. Symposium, Tokyo, Sept. 1965. Pergamon Press, Oxford and New York, 3-17.
- Amoore, J. E. 1967. Specific anosmia: A clue to the olfactory code. Nature 214:1095-1098.
- Amoore, J. E. 1968. Specific anosmias and primary odors. In "Theories of Odor and Odor Measurement," N. Tanyolac, editor, Robert College, Istanbul, Turkey, 71-81.
- Amoore, J. E., Venstrom, Delpha and Davis, A. R. 1968. Measurement of specific anosmia. Perceptual and Motor Skills 26:143-164.

- Carson, J. F. and Boggs, Lois E. 1967. The syntheses of (+) and (-) cis-S-(beta-styryl)-L-cysteine-S-oxides. J. Org. Chem. 32:673.
- Carson, J. F. 1967. Onion flavor. In "Chemistry and Physiology of Flavors," edited by H. W. Schultz, Avi Publishing Co., Westport, Conn., 390-405.
- Granroth, Bengt and Virtanen, Artturi I. 1967. S-(2-Carboxypropyl)-cysteine and its sulfoxide as precursors in the biosynthesis of cycloalliin. Acta Chemical Scandinavica 21:1654-1656. 1/
- Granroth, Bengt and Virtanen, Artturi I. 1967. On the biosynthesis of cycloalliin in the onion bulb. Suomen Kemistilehti B, 40:103-104. 1/
- Schwimmer, S. 1967. Development of bitterness in onion. Food Technol. 21:292.
- Schwimmer, S. and Guadagni, D. G. 1967. Cysteine induced odor intensification in onions and other foods. J. Food Sci. 32:405.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-
ORGANISMS AND NATURALLY OCCURRING TOXINS

Microbiology and Toxicology

- Lee, C. K. and Ordal, Z. J. 1967. Regulatory effect of pyruvate on the glucose metabolism of Clostridium thermosaccharolyticum. J. Bacteriol. 94:530.
- Pheil, C. G. and Ordal, Z. J. 1967. Sporulation of the "thermophilic anaerobes." Appl. Microbiol. 15:893-898.
- Sacks, L. E. 1967. Adenine and 2,6-diaminopurine as germinants for Bacillus macerans spores. J. Bacteriol. 94:1789-1790.

1/ Research supported by P.L. 480 funds.

SAFFLOWER, CASTOR, AND OTHER WESTERN
OILSEEDS UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	: <u>Scientist Man-Years F.Y. 1968</u>				
	: <u>Research Problem Area</u> :				
	: 406	: 407	: 702	: Total	
California (Albany)	:	:	:	:	
Chemical and Physical Investiga-	:	:	:	:	
tions to Improve Products	: -	: 1.6	: -	: 1.6	
Microbiology and Toxicology	: -	: -	: 1.0	: 1.0	
Technology--Process and Product	:	:	:	:	
Development	: 2.6	: 4.9	: -	: 7.5	
Total	: 2.6	: 6.5	: 1.0	: 10.1	

Intramural program is supplemented by extramural support representing
(a) 0.9 SMY's per year at State Agricultural Experiment Stations^{1/},
(b) 0 SMY's per year at other U.S. institutions, and (c) P.L. 480 funds
in 1 country representing 33,793 U.S. dollars equivalent per year.

^{1/} RPA 406 - Technology--Process and Product Development 0.2 SMY,
RPA 407 - Technology--Process and Product Development 0.7 SMY.

Problems and Objectives

Cash crops for diversification and rotation programs need to be increased, particularly in cotton-producing areas of the western states. Crops with potential for these programs are safflower, castor and other western oilseeds. New and improved food products, animal feedstuffs, and industrial products from these oilseeds are needed to provide markets for these crops. Also needed is research to determine whether aflatoxins present in meals are transmitted into animal products.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Developing highly stable edible safflower oils.
2. Developing industrial products from western oilseeds.
3. Developing improved animal feedstuffs from safflower and other western oilseeds.
4. Developing practical methods for production of safe-to-handle deallergenized castor pomace for feed use.
5. Demonstrating whether aflatoxins, their metabolites, and inactivation products present in peanut and cottonseed meals are transmitted into animal products.

Progress - USDA and Cooperative Programs

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

- A. Chemical Composition and Physical Properties (no current research)
- B. Flavor (no current research)
- C. Color, Texture and Other Quality Factors (no current research)
- D. Microbiology and Toxicology (no current research)
- E. Technology--Process and Product Development

1. Thermal and Oxidative Stability of Safflower Oil. Odor panel evaluations were made on potato chips fried in oleic oil (from high-oleic safflower), hydrogenated vegetable oil and cottonseed oil. Frying oils were used both with and without antioxidant. Initial preferences of the panel varied, but stability evaluations showed the chips fried in hydrogenated oil and oleic oil have at least double the life of chips fried in cottonseed oil. While the panel could differentiate between chips fried in oil with and without antioxidants, there was no significant improvement in shelf

life for those chips fried in oil with antioxidant. Odor evaluations were more sensitive to rancidity than taste tests.

2. Natural Antioxidants of Safflower Oil. The University of Arizona is conducting contract research to identify antioxidants and antioxidant systems in high-stability safflower oils. Tocopherol content of a number of safflower oils is being redetermined by improved analytical methods. Oils from high-oleic safflower have particularly long storage lives, but apparently this is due to their fatty acid composition rather than a high antioxidant content.

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL
PRODUCTS FROM FIELD CROPS

A. Chemical Composition and Physical Properties (no current research)

B. Chemical and Physical Investigations to Improve Products

1. Fatty Acid Derivatives of Castor Oil. Aminostearic acid is an attractive new fatty acid derivative which may be used to prepare polymers, detergents, etc. Improvements in yield and purity are necessary to make this product commercially attractive. Crude yields of 12-aminostearic acid, produced by reductive amination of ketostearic acid, were increased to 97%. The product contains 90% aminostearic before purification. Methyl ricinoleate was oxidized to 12-ketooleate. The latter compound isomerizes to methyl 12-keto-trans-10-octadecenoate, an α,β -unsaturated ketoester. Purification and characterization of both 12-keto-cis-9- and 12-keto-trans-10-octadecenoate were accomplished.

Results of rat-feeding tests indicate that castor wax, an excellent oil soluble thickener, can be metabolized.

C. Microbiology and Fermentation (no current research)

D. Technology--Process and Product Development

1. Urethane Polymers from Castor Oil. Diels-Alder type adducts obtained by heating mixtures of castor oil and hexachlorocyclopentadiene at 150° C. contained 25-36% Cl, had low acid contents and good storage stability. Rigid urethane foams prepared from these adducts had excellent flame resistance, high strength and low shrinkage. A series of urethane elastomers, prepared from toluene diisocyanate and combinations of polyether diols and ricinoleate esters, is being evaluated to determine the relationship of structure to properties.

2. Polymerization of Selected Monomers from Oilseeds. In contract research conducted at the University of Arizona, copolymerizations of some vinyl

esters of castor derivatives with vinyl chloride indicated that these may be internal plasticizers for the vinyl chloride polymer. The most promising of these is the vinyl ester of a low molecular weight homopolymer of 10-hydroxy decanoic acid. Some allyl derivatives of castor acids also copolymerized, though molecular weights of the copolymers were low.

3. Products of Sunflower Seed. Three American commercial varieties of sunflower seed were analyzed. Kernel varied from 46 to 69% of seed weight. Proximate analysis gave a range of 27 to 45% for oil and 14 to 16% for protein based on total seed weight. Fatty acid analysis by gas liquid chromatography indicated similar composition for the three species as follows: 6% palmitic acid, 3% stearic acid, 14% oleic acid and 77% linoleic acid. This composition is very close to that of safflower oil. A Russian sunflower variety showed 72% kernel, 37% oil and 18% protein in the whole seed. The oil from this variety contained less linoleic (65%) and more oleic acid (24%) than the American oils. Sunflower seeds contain color precursor similar to that in safflower.

4. Hydroxylated Derivatives of Linseed and Safflower Oils. Supported by P.L. 480 funds, the Regional Research Laboratory in India is conducting research to develop derivatives of oils that will be useful in the manufacture of industrial products. In the preparation of hydroxylated derivatives of linseed and safflower oil, sultone formation occurs as a result of sulphation of conjugated dienes (trans,trans and perhaps cis,cis but not cis,trans). Suitable cis,trans and trans,trans dienes were synthesized from 1,4-sultone and its derived sulphonamide. Cupric nitrate protected ethenoid unsaturation during ring opening of epoxy groups by catalytic hydrogenation. 20% Bromine was introduced into safflower oil. Replacement of bromine with hydroxyl was accomplished with several silver salts with varying results. Ag_2O /dioxane treatment yielded products free of bromine but with considerably less than quantitative replacement. Residual bromine following AgNO_2 /ethanol treatment was fully replaced with hydrogen by treatment with zinc amalgam. Treatment with NaHCO_3 /tetrahydrofuran under pressure led to poor replacement, high acid value and high conjugation. High hydroxyl values of about 160 (the best yet achieved) were obtained by selenium dioxide oxidation of safflower oil. Conjugated diene at 18% was considerably less than with methyl linoleate (35%).

5. Polymerizable Monomers from Castor Oil. P.L. 480 funds are also supporting research at the Regional Research Laboratory in India to prepare intermediates from castor oil hydroxy unsaturated fatty acids that would be useful in making polymers, protective coatings, adhesives and other products. Sixteen additional new polymerizable monomers were synthesized from castor oil. A majority were derived from undecylenic acid (a pyrolysis product of castor oil) and a few from sebacic acid (a cracked product of sodium ricinoleate) and 12-hydroxystearic acid. The monomers synthesized were vinyl, acrylic and allyl ethers or esters.

6. Conversion of Castor Oil Monoglycerides. The Shri Ram Institute for Industrial Research in India, supported by P.L. 480 funds, is conducting research to prepare and characterize triacylated monoglycerides of ricinoleic acid and evaluate them as plasticizers. Triricinolein, substantially free from nonhydroxy fatty acid glycerides, was isolated from castor oil by liquid-liquid extraction. However, a tendency for the product to lose water and polymerize made difficult the conversion to monoricinolein. Enriching the mixed ricinoleates produced by glycerolysis of castor oil made possible the recovery of 95% monoglycerides calculated as monoricinolein. Nearly pure triacylated monoricinolein was obtained by acetylation followed by stripping. Acetyl, propionyl and n-butyryl ricinoleates were prepared. Alpha-monoricinolein was synthesized by transesterification of methyl ricinoleate with isopropylidene-glycerol and hydrolysis of isopropylidene-glycerol ester.

7. Metal-catalyzed Oxidation of Castor Oil. Supported by P.L. 480 funds, the Madras Christian College in India has initiated an investigation of low-cost catalytic processes for preparation of industrially useful unsaturated ketones and trihydroxystearates from castor oil.

8. Components of Safflower. High lysine varieties of safflower were replanted and the second generation seeds also had a high lysine content. Isolation and separation of bitter components and removal of laxative principle from safflower meal are underway. Thin-hull brown-stripe safflower varieties produce 17-25% more oil than commercial seeds, but the oil is of lower quality because of undesirable color and odors. The dark color is formed from colorless precursors. These are phosphatides which can be removed by water treatment or alkali extraction. Odorous components are also removed by alkali extraction and steam stripping, but they tend to reappear on storage of the oils. Extraction of oil at low temperatures and treatment with bleaching clay appear to be the best methods for removing odor precursors.

9. Improved Feeds from Deallergenized Castor Pomace. Steam-treated and ammonia-treated pomace have been prepared for use in a cattle feeding trial. Deallergenized castor meal will be compared with undeallergenized meal and with cottonseed meal. A previous trial showed steamed pomace superior to lime treated pomace.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-
ORGANISMS AND NATURALLY OCCURRING TOXINS

A. Chemical Composition and Physical Properties (no current research)

B. Microbiology and Toxicology

1. Transmission of Aflatoxin into Animal Products. The possibility of transmission of aflatoxin into the meat and eggs of poultry fed rations containing known amounts of aflatoxin was investigated. To date two levels of aflatoxin (1650 and 825 parts per billion aflatoxin) have been fed to chicks from day-old to 8 weeks of age under simulated commercial broiler feeding practices. On the basis of growth, mortality, hematology, biochemical and tissue enzyme analyses and histological evaluations, it was concluded that some liver abnormalities were related to aflatoxin ingestion, especially when the chicks were under 4 weeks of age.

C. Technology--Process and Product Development (no current research)

Publications - USDA and Cooperative Program

RPA 406 - NEW AND IMPROVED FOOD PRODUCTS FROM FIELD CROPS

Technology--Process and Product Development

Applewhite, T. H. 1967. Composition of safflower oil. ARS 74-43, p. 41.

Bratcher, S. and Kemmerer, A. R. 1967. Natural antioxidants in safflower oil. ARS 74-43, p. 53.

Fuller, G. 1967. High-temperature stability of safflower oil. ARS 74-43, p. 58.

RPA 407 - NEW AND IMPROVED FEED, TEXTILE AND INDUSTRIAL PRODUCTS FROM FIELD CROPS

Chemical and Physical Investigations to Improve Products

Diamond, M. J. and Applewhite, T. H. 1967. Alkaline cleavage of hydroxy unsaturated fatty acids and derivatives. II. 10-Hydroxy-decanoic acid from ricinoleates and 1,10-decanediol from ricinoleyl alcohol. J. Am. Oil Chemists' Soc. 44:656.

Technology--Process and Product Development

Binder, R. G. and Burkhardt, H. J. 1967. Color and odor problems in safflower oil. ARS 74-43, pp. 37-41.

Burkhardt, H. J. 1968. Color problems in oils from experimental safflower varieties. J. Am. Oil Chem. Soc. 45:96-9.

Chow, R. C. L. and Marvel, C. S. 1967. Copolymers of methyl 12-acryloxy-stearate and vinyl chloride. J. Polymer Sci. 5:2949-51.

Chow, R. C. L. and Marvel, C. S. 1968. Preparation and copolymerization of vinyl 10,11-epoxyundecanoate. J. Polymer Sci. 6:1273-79.

- Chow, R. C. L. and Marvel, C. S. 1968. Copolymerization of allyl esters of some fatty acids. J. Polymer Sci. 6:1515-21.
- Goodban, A. E. 1967. Safflower protein products for food use. ARS 74-43, pp. 92-5.
- Guggolz, J. 1967. Composition of safflower seed. ARS 74-43, pp. 31-6.
- Kohler, G. O. and Palter, R. 1967. Amino acid composition of safflower meal--A fast hydrolysis procedure. ARS 74-43, pp. 95-8.
- Kuzmicky, D. D. 1967. Safflower meal in poultry rations. ARS 74-43, pp. 80-2.
- Liepins, R. and Marvel, C. S. 1967. Homopolymers and copolymers of acrylates and methacrylates of homoterpenylmethyl carbinol and alpha-campholenol. J. Polymer Sci. 5:1489-99.
- Liepins, R., Marvel, C. S., and Lyon, C. K. 1967. Polymers of the vinyl esters of perchlorocyclopentadiene adducts of petroselinic and oleic acids. J. Polymer Sci. 5:1809-25.
- Liepins, R. and Marvel, C. S. 1967. Reaction of triethyl phosphite with vinyl esters. J. Polymer Sci. 5:2453-54.
- Liepins, R. and Marvel C. S. 1967. Homopolymers and vinyl chloride copolymers of vinyl esters of chlorinated fatty acids from Umbelliferae and Limnanthes Douglas II. J. Polymer Sci. 5:2899-2909.
- Liepins, R., Marvel, C. S., and Magne, F. C. 1967. Vinyl chloride acrylate of methoxy poly(ethylene glycol) copolymers. J. Polymer Sci. 5:2946-48.
- Lyon, C. K., Fuller, G., and Applewhite, T. H. 1967. Rate of reaction of hexahalocyclopentadienes with long-chain olefins. J. Amer. Oil Chem. Soc. 44:740-42.
- Mottola, A. C., Kohler, G. O., and Prescott, R. T. 1967. Allergen deactivation in castor pomace with steam. Feedstuff 39:20.
- Noma, A. T., Ricci, B. A., and White, L. M. 1967. Lysine content of single safflower kernels. ARS 74-43, pp. 103-5.
- Rao, G. Venkateswara and Achaya, K. T. 1967. Estimation of carboxyl, sulphate and sulphonate groups by direct titrimetry. Indian J. Chem. 5:150-52. 1/

1/ Research supported by P.L. 480 funds.

White, L. M. and Gauger, M. A. 1967. Application of automated analysis to estimations of lysine and total amino acids in safflower seed hydrolysates. ARS 74-43, pp. 99-102.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-
ORGANISMS AND NATURALLY OCCURRING TOXINS

Microbiology and Toxicology

Garrett, W. N., Heitman, H., Jr., and Booth, A. N. 1968. Aflatoxin toxicity in beef cattle. Proc. Soc. Expt. Biol. & Med. 127:188-90.

Hintz, H. F., Heitman, H., Jr., Booth, A. N., and Gagne, W. E. 1967. Effects of aflatoxin on reproduction in swine. Proc. Soc. Expt. Biol. & Med. 126:146-48.

POULTRY UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968		
	Research Problem Area :		
	410	702	Total
California (Albany)			
Flavor	5.0	-	5.0
Color, Texture and Other Quality Factors	7.0	-	7.0
Microbiology and Toxicology	-	3.0	3.0
Technology--Process and Product Development	0.4	-	0.4
Total	12.4	3.0	15.4

Intramural program is supplemented by extramural support representing
 (a) 0.2 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0.7 SMY's per year at other U.S. institutions^{2/} and (c) no P.L. 480 grants.

1/ RPA 410 - Technology--Process and Product Development 0.2 SMY.

2/ RPA 410 - Chemical Composition and Physical Properties 0.7 SMY.

Problems and Objectives

Since World War II, per capita consumption of chicken and turkey meat has doubled; ready-to-cook and ready-to-warm-and-serve retail products have been made available; the scale of individual commercial operations has expanded 10- to 20-fold; and vertical integration has linked breeder, hatchery, producer, and processor into vast economic aggregates. However, the retail price of the products has remained unchanged. Because of this price situation, with its narrow profit margins, new, more efficient processes and new, more convenient and appealing products are needed. Also, wholesomeness, particularly freedom from Salmonella, has become increasingly important as more poultry is processed into precooked forms that only require rewarming to serve. There is need to develop better sanitation in processing and to develop and incorporate pasteurization steps for some products so as to insure a completely safe consumer product.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Controlling Salmonella in poultry meat products.
2. Eliminating aging requirement for frozen poultry.
3. Developing integrated use of further processed poultry.
4. Improving freeze drying of poultry.

Progress - USDA and Cooperative Programs

RPA 410 - NEW AND IMPROVED MEAT, MILK AND EGG PRODUCTS

A. Chemical Composition and Physical Properties

1. Microstructure of Poultry Muscle. Contract research is conducted at the American Foundation for Biological Research, Madison, Wisconsin, to obtain information needed for the possible elimination of the aging requirement for frozen poultry. Glycogen depleted muscles that were allowed to contract were more tender than restrained glycogen depleted muscles. These results contradict many views that link post mortem shortening through thaw-rigor or other stimulations with toughening. In electron microscopy studies, the principal effect of glycogen depletion appeared to be a disturbance of the interfibrillar areas, where the normally observed mitochondria and endoplasmic reticulum are replaced by disorganized agglomerations. Shortening and shear (toughness) values of muscles after thawing and immediate cooking were obtained for restrained muscle frozen 10 minutes, 20 minutes, 2 hours and 24 hours after slaughter. Shortening as percentage of original length was 62, 66, 33, and 0, respectively. Average shear values were 76, 81, 80, and 46, respectively. Restrained muscles for the 10 and 20-minute delay periods were approximately twice as tough as the unrestrained muscles.

Ultrastructural disintegration due to thaw rigor began 10 minutes after completion of thawing. Twenty-five minutes after complete thawing, contents of the whole muscle bundle were granular.

B. Flavor

1. Chemical Nature of Cooked Poultry Aroma. Because cooked and fabricated poultry products are much more likely to develop off-flavors than raw poultry, information on the chemistry of cooked poultry aroma is necessary for developing the use of further processed poultry. A number of alkanals, 2-enals, ketones, substituted furans, hydrocarbons, and benzaldehyde have been identified in the aroma isolate from roast turkey drippings. Also, acetaldehyde and acetone were detected in a CaCl_2 chicken aroma fraction.

Rapid fading of the yellow in chicken fat has aroused interest in carotenoid pigments as potential precursors of aroma components. Thermal decomposition products of beta-carotene and of lutein appear to be generally similar and fairly complex. Toluene, xylene, and dimethylnaphthalene were identified as major decomposition products of carotene.

C. Color, Texture, and Other Quality Factors

1. Post Mortem Reactions of Muscle Proteins. Susceptibility of chicken muscle myofibrils to mechanical fragmentation was investigated as a microscopic index of tenderness. Short myofibrillar segments were associated with more tender muscle both in pre-rigor and in 24-hour aged muscle. Tough muscle was related to long myofibrils with the exception of muscle treated to prevent pH decline. This muscle exhibited a constant intermediate shear value, with the proportion of long myofibrils decreasing slowly during aging.

Highly purified preparations of actin, the myofibrillar protein, were subjected to the action of carboxypeptidase A. Phenylalanine was the only amino acid detected in the enzyme digests.

Proteolytic activity in breast muscle extracts was about twice that in leg muscle extracts.

Breast muscles were analyzed spectrophotometrically for protein and non-protein sulfhydryl at 0, 15, 30, 45, 60, 120, 240, and 360 minutes post mortem. No significant changes were observed.

This investigation provides information needed for the possible elimination of the aging requirement for frozen poultry.

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development

1. Meat Emulsion--Sausage Type Products. Procedures for experimental sausage formulations and preparation and techniques for examination and

evaluation of the emulsions have been developed in contract research at the University of Nebraska. Preliminary tests indicate that the salt soluble proteins of turkey meat have superior emulsifying capacity.

This investigation will provide information needed for the development of integrated use of further processed poultry.

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS
AND NATURALLY OCCURRING TOXINS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor (no current research)

C. Color, Texture, and Other Quality Factors (no current research)

D. Microbiology and Toxicology

1. Elimination of Pathogens and Reduction of Spoilage Bacteria. It is recognized that the destruction of Salmonella and other microorganisms on the surfaces of poultry is very difficult without modifying the product's appearance. The possibility that a fat miscible solvent as a suspending medium for bactericides would increase their effectiveness was tested with negative results. A variety of tests confirmed the view that the physical topography of the bird protects the microorganisms from the bactericide. Short-time chemical treatments applied by dipping or spraying seem unlikely to reach all Salmonella on surfaces to constitute an effective pasteurization treatment.

The poor results from chemical pasteurization treatments give weight to approaches designed to reduce initial contamination. This would involve two main steps: Development of improved sanitation practices in processing plants to reduce contamination and the spread thereof during processing, and development of improved farm management practices to reduce flock contamination thereby reducing the Salmonella load brought to the plant.

E. Technology--Process and Product Development (no current research)

Publications - USDA and Cooperative Program

RPA 410 - NEW AND IMPROVED MEAT, MILK AND EGG PRODUCTS

Flavor

Nonaka, M., Black, D. R., and Pippen, E. L. 1967. Gas chromatographic and mass spectral analyses of cooked chicken meat volatiles. J. Agr. Food Chem. 15:713-17.

Weil, Jair T. and Windle, J. W. 1968. The electron spin resonance study of nitroxide radicals from diethylhydroxylamine dioctylhydroxylamine and N-hydroxypyrrolidine. Nature 217:842.

Color, Texture, and Other Quality Factors

de Fremery, D. 1967. Can post mortem tenderization of poultry meat be explained by dissociation of F-actin, polymerized myosin or actomyosin? Poultry Sci. 46:1251-1252.

Pool, M. F. 1967. Objective measurement of connective tissue tenacity of poultry meat. J. Food Sci. 32:550-553.

Scholtyssek, S. and Klose, A. A. 1967. Sources of variability in turkey tenderness. Poultry Sci. 46:936-38.

Scholtyssek, S., Bele, L. M., Sayre, R. N., and Klose, A. A. 1967. Tenderness of dystrophic chicken meat. Poultry Sci. 46:1050-53.

EGG UTILIZATION

USDA and Cooperative Program

Location of Intramural Work	Scientist Man-Years F.Y. 1968		
	Research Problem Area :		
	410	702	Total
California (Albany)	:	:	:
Chemical Composition and Physical Properties	6.0	-	6.0
Microbiology and Toxicology	-	8.0	8.0
Total	6.0	8.0	14.0

Intramural program is supplemented by extramural support representing
 (a) 0.6 SMY's per year at State Agricultural Experiment Stations^{1/},
 (b) 0.5 SMY's per year at other U.S. institutions,^{2/} and (c) P.L. 480
 funds in 1 country representing 9,526 U.S. dollars equivalent per year.

1/ RPA 702 - Microbiology and Toxicology 0.6 SMY.

2/ RPA 410 - Chemical Composition and Physical Properties 0.5 SMY.

Problems and Objectives

Between 1956 and 1966 egg production increased from 61 to 66 billion eggs, but per capita consumption decreased to 85% of the 1956 value. The decrease in per capita consumption reflects a decrease in table egg use. The per capita use of egg products, eggs removed from the shell and further processed is estimated to have increased during the past decade. Egg product use amounts to about 10% of the total consumption. The increase in egg product use and the consumer demand for convenience foods indicate that further efforts to increase egg product consumption by developing new and improved products will help to reverse the downward per capita trend of egg consumption. Also, for each of the many types and blends of egg products, there is need to determine what treatments will provide maximum kills of salmonellae without destroying any substantial amount of the egg's functional properties.

Major objectives of the research are to develop and evaluate alternative ways for:

1. Eliminating processing damage to egg products.
2. Controlling Salmonella in liquid and dried eggs.

Progress - USDA and Cooperative Programs

RPA 410 - NEW AND IMPROVED MEAT, MILK AND EGG PRODUCTS

A. Chemical Composition and Physical Properties

1. Properties of Products Related to Specific Proteins. The disulfide bonds of ovomucoid are split by hydroxide ion at room temperature. The kinetics and stoichiometry of this splitting have been determined. Since the composition of ovomucoid is so similar to ovomucin, the "structural protein" of egg white, it is conceivable that the thinning of egg white on storage is caused by alkaline hydrolysis of the disulfide bonds of ovomucin. The rate of decrease in viscosity of egg white is proportional to hydroxide ion concentration. There is no decrease in viscosity when ovomucin is removed.

2. Modification of Egg White. In contract research at the Iowa State University in Ames, the effects on functional properties of several chemical and physical treatments of egg white were evaluated. Chemical changes were not always associated with functional changes. Oxidation of egg white with potassium persulfate altered tyrosine, cystine, and tryptophane. The changes correlated with reduced performance in angel cake. Acylating agents altered amino groups (especially lysine) and SH groups, with gross changes in lysozyme resolution and mobility in electrophoresis. Aerating foam stability and heat denaturation properties were reduced with high acylation, but improved at low levels. Sodium dodecyl sulfate altered

electrophoretic mobility, heterogeneity, viscosity, and lysozyme activity, without affecting angel cake performance, and with some increase in emulsifying ability. Tannic acid reduced emulsifying ability. Reducing agents decreased iron binding capacity, heat stability, angel cake performance and inactivated lysozyme. Acrylonitrile stabilized egg white to heat.

3. Freezing Effects on Egg Yolk Protein. Supported by P.L. 480 funds, the Indian Institute of Science in Bangalore, India, is conducting research to determine the physical-chemical nature of changes in egg yolk components caused by freezing and thawing. Biogel-fractionated soluble and gel proteins obtained by formic acid delipidation of egg yolk plasma were analyzed for hexose and sialic acid. All fractions were glycoproteins containing hexoses and sialic acid.

B. Flavor (no current research)

C. Color, Texture, and Other Quality Factors (no current research)

D. Microbiology and Toxicology (no current research)

E. Technology--Process and Product Development (no current research)

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICRO-
ORGANISMS AND NATURALLY OCCURRING TOXINS

A. Chemical Composition and Physical Properties (no current research)

B. Flavor (no current research)

C. Color, Texture, and Other Quality Factors (no current research)

D. Microbiology and Toxicology

1. Heat Resistance of Salmonella. Test results seem to negate previous suggestions that the difference in heat resistance between Salmonella senftenberg 775W and S. senftenberg 197B lies in the difference in strength of the cell envelope. Cells of the two strains were subjected to various physical and chemical agents that are known to alter the integrity of the cell in an attempt to correlate resistance to these agents with resistance to heat. No difference between the two strains was found in sensitivity to sound waves, to freezing and thawing, to the surface active agent sodium lauryl sulfate and to the chelating agent ethylenediaminetetraacetic acid.

Present specifications require that all egg products are to be pasteurized by treatments that give kills equivalent to that obtained by heating whole egg to 140° F. and holding for 3.5 minutes. It was found that for a 3.5 minute hold, egg white must be heated to 134° F., yolk to 142°, and sugared and salted yolk to about 148° for equal kills. Whites show some damage at 134° F. but the other products are not damaged at the indicated temperature. These and other results are being used as a

basis for changing pasteurization specifications. Pasteurization by UV radiation was successful in the laboratory, but engineering studies showed it to be uneconomic on a large scale. Special methods were developed for measuring holding times for liquid egg products in pasteurizers, laminar flow dominates, fastest moving particles are retained about 70% as long as average particle. An improved method was developed for pasteurizing salt yolk for use in mayonnaise and salad dressing: acetic acid added before pasteurizing rather than later lowers temperature required. An egg pasteurization manual has been written and is expected to be published in 1968.

2. Selenium Metabolism of Salmonella. Supported by a research grant, Cornell University in New York developed a modification in the preparation of the selenite medium used for analysis of Salmonella in egg white that should improve isolation efficiency. Separate sterilization of sodium selenite eliminates reduction of selenite to elemental selenium, and thus provides more accurate control of inhibitor concentration. A quantitative method for the determination of selenomethionine and selenocystine in the presence of sulfur amino acids has been developed. Use of sodium cyanide as an inhibitor prevents selenite reduction to elemental selenium, but does not prevent the incorporation of selenium into the proteins of growing E. coli cells.

3. Changes Induced by Pasteurization. In contract research at the University of California in Davis, studies of the reactions of formaldehyde with egg proteins are being completed and the information prepared for publication. The effect of peroxide on the nutritionally essential amino acid methionine is being evaluated. The accelerated oxidation of yolk lipid when treated with phospholipase A, which hydrolyzes glycerides at the beta position, indicates the importance of lipid structure on oxidative stability. Information on the effect of peroxide on lipid sensitivity to oxidation is being prepared for publication.

E. Technology--Process and Product Development (no current research)

Publications - USDA and Cooperative Program

RPA 410 - NEW AND IMPROVED MEAT, MILK AND EGG PRODUCTS

Chemical Composition and Physical Properties

Cunningham, F. E. and Lineweaver, Hans. 1967. Inactivation of lysozyme by native ovalbumin. Poultry Sci. 46:1471-77.

Donovan, J. W., Davis, J. G., and Park, L. U. 1967. Sugar nucleotides of chicken egg white. Archives of Biochemistry and Biophysics 122:17-23.

Donovan, John W. 1967. A spectrophotometric and spectrofluorometric study of intramolecular interactions of phenolic groups in ovomucoid. Biochemistry 6:3918-3927.

Donovan, John W. 1967. Spectrophotometric observation of the alkaline hydrolysis of protein disulfide bonds. Biochemical and Biophysical Research Communications 29:734-740.

Donovan, J. W. 1968. Short wavelength ultraviolet absorption changes produced by conformation changes of proteins. Federation Proceedings 27:337.

Smith, M. B. and Back, Joan F. 1968. Studies on ovalbumin. III. Denaturation of ovalbumin and S-ovalbumin. IV. Trypsin digestion and the cystine peptides of ovalbumin and S-ovalbumin. Aust. J. Biol. Sci. 21:539. 1/

RPA 702 - PROTECT FOOD SUPPLIES FROM HARMFUL MICROORGANISMS
AND NATURALLY OCCURRING TOXINS

Kraft, A. A., Torrey, G. S., Ayres, J. C., and Forsythe, R. H. 1967. Factors influencing bacterial contamination of commercially produced liquid egg. Poultry Sci. 46:1204-10.

1/ Research supported by P.L. 480 funds